# Operation Analysis and Control: A Paradigm Shift in Construction Safety Management

**Critical Review**

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# **G**raduate **R**esearch **O**ffice

*Swyddfa Ymchwil Graddedigion*

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Thank you all, Ciaran
February 2016.

"*Engineering isn't about perfect solutions; it's about doing the best you can with limited resources*"

Randy Pausch (2008)

## Abbreviations

| | |
|---|---|
| ACoP | Approved Code of Practice |
| ASSE | American Society of Safety Engineers |
| CDM | Construction, Design and Management |
| CPD | Continuing Professional Development |
| CQI | Chartered Quality Institute |
| CSSE | Canadian Society of Safety Engineering |
| DSAC | Design safety analysis and control |
| EASHW | European Agency for Safety and Health at Work |
| EC | European Council |
| EU | Europe Union |
| EU-OSHA | European Occupational Safety and Health Administration |
| HEA | Higher Education Authority |
| HSA | Health and Safety Authority [Ireland] |
| HSE | Health and Safety Executive [GB] |
| HSENI | Health and Safety Executive Northern Ireland |
| HSWA | Health and Safety at Work etc. Act |
| ICE | Institution of Civil Engineers |

| | |
|---|---|
| IEA | International Engineering Alliance |
| ILO | International Labour Organisation |
| IOSH | Institution of Occupational Safety and Health [UK] |
| ISO | International Organization for Standardization |
| ISSA | International Social Security Association |
| OAC | Operation Analysis and Control |
| OCMI | Organisation Cultural Maturity Index |
| OECD | Organisation for Economic Cooperation and Development |
| OSHA | Occupational Safety and Health Administration [USA] |
| OSHMS | Occupational Safety and Health Management Systems [ILO] |
| PBL | Problem Based Learning |
| PtD | Prevention Through Design |
| QAA | Quality Assurance Agency |
| StD | Safety through Design |
| SiD | Safety in Design |
| UK SPEC | UK Standard for Professional Engineering Competence |
| VZI | Vision Zero Initiative (Sweden) |

## Glossary

| | |
|---|---|
| Core premise: | Intellectually and technologically we have the capacity to deliver on vision zero. |
| Critical consciousness (aka conscientization): | An understanding of causality, a grasp of the processes of history, and the ability to translate thought into action |
| Dialogics: | How the past is altered by the present as much as the present is directed by the past. |
| Inherently safe[r] design | Where designs are such that they can be built, used, maintained and eventually demolished without harming the safety health and wellbeing of those who work on the structure or are affected by it. |
| Linguistic Analysis | Used to describe and interpret the unconscious rules and processes that speakers of a language use to create the spoken and written word. |
| Praxis: | That is recognising the need to go beyond interpreting the world in various ways to the point where you change it. |
| Social constructionism: | The world as socially constructed by the people within it through their everyday interactions and practices |
| Social constructivist: | Emphasises how meanings and understandings emerge from social encounters. |
| Sociolinguistics: | Exploring the effect society has on the language. |
| Sociology of language: | Examining the effect that language has on society. |
| Vision zero [harm] | Vision zero or ‘Zero Harm’, as it is sometimes called, is a way of thinking that works on the principle that no-one, regardless of involvement, will be adversely affected by the company’s activities. At the very least addressing zero fatalities, zero life changing incidents to the very best of total zero harm. |

## About the author's experience

The author, a chartered civil engineer working in the industry since 1978, designed and managed water industry civil engineering projects (treatment plants, reservoirs, pipelines, pumping stations). While working on strategy and policy implementation in the road construction industry the author developed and implemented health and safety, environmental and road design standards for the Design Manual for Roads and Bridges (DMRB) and the Manual of Contract Documents for Highway Works (MCHW). As senior engineer in strategic roads implementation team the author managed major road construction projects before joining the faculty at the Ulster University in 2010

Through the years, from 1997 the author’s work, with its cross-jurisdictional and cross-industry emphasis has had a strong focus on safety, health and wellbeing in construction, specifically prevention through design (PtD). The author has been an active researcher, educator and writer of professional papers, and scholarly work in the field of safety, health and wellbeing and environmental management since the early 1990s. The author’s initial interest was inspired by the emergence of a plethora of safety, health and wellbeing regulations emanating from the European Union (EU), applicable to all Member States, which were beginning to significantly impact upon all facets of industry in the UK. There was a raft of new regulations impacting on the UK construction industry related to many of the so-called ‘high hazards’ aspects (either by activity or by article), including areas such as: chemicals and substances, noise, vibration, lifting operations, confined spaces. Additionally, new specific regulations relating to construction (design and management), also came out of the EU around the same time. Throughout the period of the 1990s the range of regulatory requirements grew significantly as did the compliance challenges on the construction industry. The issues, however, were not unique to the EU Member States since around the same time other countries were starting to focus their attention on specific regulatory requirements in similar fields.

The author's contribution to innovative prevention practices started with the development of the OAC model for managing safety; a model that was recognised in 2006 as being internationally excellent in terms of originality, significance and rigour by the International Social Security Association (ISSA). The OAC model, having gained this recognition was awarded the IMHOTEP Prize for 'Good Innovative Prevention Practices' at the XXVIII International Symposium of the ISSA Construction Section on Occupational Health & Safety. The Good Innovative Prevention Practices Award centred on contributions to innovative prevention practices that worked across industries and across national boundaries.

The author was also the recipient of the 1999 IOSH/ Zurich Municipal Supreme Safety Award for the design and introduction of a quality based health and safety management system, which applied the first iteration of OAC and later received the 2001 National Irish Safety Organisation Occupational Safety Awards (Northern Ireland Regional).

*"A mind doesn't make a mistake, just like that. There is a reason."*

Winnie Mandela (1986)

## Abstract

In the 1990s the author embarked upon a project that would fundamentally alter the theoretical basis of safety, health and wellbeing management in the construction sector and beyond. The emerging risk management approach was flawed, relying on an element of chance to deliver safe outcomes. The author's research into development and delivery of the Operation Analysis and Control (OAC) led to the realisation that vision zero (or zero harm) was achievable, given the intellectual and technological capability at our disposal. What was missing was an understanding of the delivery mechanisms, how in fact could the intellect and technology be positively exploited to make zero harm a real possibility. The OAC model, developed from first principles, free from preconceived notions, attached to the then risk assessment (and the emerging risk management) approaches was so unencumbered that it was to become recognised by ISSA for its cross-jurisdictional and cross-disciplinary nature.

The major thrust has been to establish the efficacy of the OAC approach within the construction industry. While OAC was in essence a model with a focus on designing operation processes, leading ultimately to zero harm there was another side to the coin, namely safe design or more correctly inherently safe[r] design, the ability to deliver on the prevention through design agenda. Here the OAC had a direct impact on the aim of delivering prevention through design, becoming a major feature of the PtD education approach, demonstrating a strong inter-relationship between the projects.

Delivering safety management as a quality systems approach set a new theoretical foundation upon which future health and safety education, training and performance could be built. The new paradigm (OAC) put workers at the heart of safety management, not as an adjunct as was implied in the accepted norm at the time. The production and proving of the OAC model and the scholastic work associated with developing Prevention through Design (PtD) learning and teaching packages are examples of outputs from the author's original work in safety, health and wellbeing. The original and guiding premise was that:

"Technologically and intellectually we have it within our capability to [deliver vision zero] prevent fatal or life altering accidents from ever occurring…"

Workers need to be at the heart of safety management not external agents affected by its consequences and with acceptance of competence and agency (active participation) comes cognition; the ability for workers to challenge their historical and social situation.

This thesis presents a critical reflection of the author's work, using two major projects as exemplar outputs; OAC model and Prevention through Design education. The reflection discusses the interrelationship between the projects, including a synthesis of the author's work as demonstrated by the projects presented. There is commentary on the current standing of the projects together with a critical review of the significant and original contribution the author's work makes to the academic field of construction safety, health and wellbeing.

A concluding chapter addresses lessons learnt and advances the author's thoughts on further research in this area, exploring where the OAC model and Prevention through Design should go next in pursuit of vision zero harm in construction.

# Chapter 1. Introduction

## 1.1 Aims of the review

This review sets out to explain the rationale behind the author's research and development work in the field of safety, health and wellbeing since the early 1990s. Through the use of two significant exemplar project outputs the author seeks to demonstrate that a sufficiently high level of work, worthy of the award of PhD by portfolio, has been produced in the intervening period. The review will comprise a critical reflection of the two projects; their use and their value to the design and construction community, indicating where appropriate their relevance and impact. The exemplar projects:

1. Project 1: Operation Analysis and Control (OAC) - detailed reflection and critique presented in Chapter 4
2. Project 2: Prevention through Design (PtD) Education - detailed reflection and critique presented in Chapter 5.

This synthesis of the author's work is supplemented by substantial evidence in the form of published papers, books, book chapters, databases, CDs and websites as well as audit and accident reports. A full training package for the Prevention through Design training project and the evaluation document from the MEng/ BEng safety Engineering and Disaster Management degree programme, offered at Ulster University is available, as are the relevant papers published over the years (and appropriately referenced in this critical reflection). This review demonstrates, across the range of work presented and critiqued, that there has been the creation and interpretation of new knowledge. In presenting the original research and advanced scholarship in the field of civil engineering construction and design the thesis also discusses the appropriate nature of the chosen research methods and their applicability in the delivery of the project outputs.

The core premise guiding author's research and publications has always been that intellectually and technologically we have the capacity to deliver on vision zero.

## 1.2 Structure of the review

The review will discuss originality across a number of key themes:

- Vision zero as it relates to construction;
- Technical and Intellectual capacity to deliver vision zero;
- Prevention through design;
- Safe to start, safe to execute and safe to finish; and
- Competent to become competent

This originality discussion is followed by a critical reflection of the research methodologies, including a discussion on the application of systems thinking to safety, health and wellbeing, before moving on to discuss the use of dialogics[1] and praxis[2] in the development of the Operation Analysis and Control (OAC) model for safety; a paradigm shift in construction safety management.

A reflective interpretation of the exemplar projects follows with supporting evidence where appropriate. With each project the author offers a justification for its design and delivery as well as a critique of its successful implementation. The review concludes with a chapter contemplating the impact of the original contributions, what the future holds for safety, health and wellbeing research in in construction and the lessons learnt along the ways.

## 1.3 Background to the exemplar projects

In the 1990s the author embarked upon a project that would fundamentally alter the theoretical basis of safety, health and wellbeing management in the construction sector and beyond. The emerging risk management approach was flawed, relying on an element of chance to deliver safe outcomes.

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[1] How the past is altered by the present as much as the present is directed by the past.
[2] That is recognising the need to go beyond interpreting the world in various ways to the point where you change it.

From an early and close examination of confined spaces entry fatalities the author developed a management approach, focused on delivering a ‘no deaths in confined spaces’ agenda. The early developments in this ‘no deaths’ or ‘towards zero fatalities’ approach (McAleenan and McAleenan 1999), introduced an original thought to safety management, which developed into a model with the capacity to expand across all facets of safety, health and wellbeing.

What emerged was the OAC model, developed from first principles, free from preconceived notions, attached to the then risk assessment (and the emerging risk management) approaches. Consequently, since OAC was so creative in its outlook it became recognised by ISSA for its cross-jurisdictional and cross-disciplinary nature. Nevertheless, the major thrust has been to establish the efficacy of the OAC approach within the construction industry, an industry with a sufficiently poor accident track record, an industry that could benefit from an enthusiastic boost in its delivery of safe and healthy projects. While OAC was primarily designed with a focus on designing a safe operation or process leading ultimately to vision zero harm there was another aspect to consider, its ability to deliver prevention through design.

A specific iteration of OAC, design safety analysis and control (DSAC), Table 1.1, concentrated on PtD and on the built environment (McAleenan and McAleenan 2004). DSAC became central to the delivery of the PtD ethos and formed the mainstay of the educational work that was to follow.

Table 1.1: Design Safety Analysis and Control [PtD]

| **Stage** | **Key Questions for Designers** |
|---|---|
| Analysis | What are the sources of harm presented by the project?<br>What is to be done to eliminate or control them?<br>Are the controls effective? |
| Management | What are the sources of harm presented by the project?<br>What is to be done to eliminate or control them?<br>Are the controls effective? |
| Effectiveness review | How well is the project progressing?<br>What design changes are necessary to ensure project success?<br>When should the next review take place? |

## 1.4 Original contributions and interrelationships between projects

Critical theory explains what is wrong with the current social reality, identifies the actors who can change it and provides the clear norms for achievable practical goals for social transformation. Operational analysis and control was developed on the premise that workers, engaged in the decision making process, where they have direct involvement in the work can and will make the right decisions, that is the decisions that will have a positive impact on their safety, health and wellbeing. The change that such an approach made on the worker and the worker's environment was, what is often referred to in more recent times as empowerment yet such a term is a disservice to the value such changes to workers' involvement truly make. Autonomy and agency (McAleenan and McAleenan, 2014) is a much more powerful description as it was that new dynamic that recognised and encouraged a worker driven collaboration with management that delivered real improvement in safety, health and wellbeing across the whole of the workplace (Freire, 1973; Garavan, 1997; Ayers and McAleenan, 2008; McAleenan and McAleenan, 2008).

The successful implementation of OAC in the initial stages of development and delivery relied upon the author as the champion, being close at hand and having excellent persuasive powers, particularly since as safety engineer and advisor to the organisation position power was not an option. However senior management accepting the premise and commitment to its successful implementation made the transition to the new regime much smoother.

Extending the OAC ideas and ideals from the worker to the designer, placing a strong responsibility and presenting a great opportunity, was evident in the emerging prevention through design approach of the early 2001s defined as the capacity to deliver project designs that could be built, used, maintained and eventually demolished without causing harm to workers or anyone impacted by the structure (McAleenan and McAleenan, 2004). A thought implicit in the Robens Report (Robens, 1972) and in the Health and Safety at Work etc. Act 1974 (OPSI, 1974), and a requirement in the UK Standard for Professional Engineering Competence (Engineering Council, 2014) but one that has yet to be completely addressed in the engineering design community.

Fittingly, OAC was capable of being customised and a derivation; Design Safety Analysis and Control (DSAC), was formed; the embodiment of prevention through design (PtD) and a clearly practical way forward for designers (McAleenan and McAleenan, 2004). However, despite the apparent straightforwardness of the approach it was apparent to the author that what was needed was education, across the spectrum to ensure that the underlying principles and associated processes, necessary to successfully deliver on PtD, became a part of the engineers' psyche.

The essence of good engineering is the bringing together art and science to deliver projects that truly benefit the wellbeing of society. The education process to embed PtD would have to involve experienced and developing designers and consequently the vehicle for delivery needed to be diverse, flexible, robust, reliable and cognisant of the fact that there are many routes followed in the development of engineering competence (McAleenan and McAleenan, 2009; 2010; 2011; Tymvios et al, 2015).

Laterally the author co-developed the Organisation Cultural Maturity Index (OCMI), which was initially developed to give a numerical value to indicators otherwise considered intangible (McAleenan and McAleenan, 2009: 2011; 2014). The unexpected discovery within OCMI was the diagnostic functionality of the product (McAleenan and McAleenan, 2014). The two models OAC (McAleenan and McAleenan, 2001; 2002) and OCMI (McAleenan and McAleenan, 2009: 2011; 2014), although designed years apart are integral tools for successful safety management in the construction industry.

The author now believes that any organisation seeking to implement an OAC/ PtD approach should start with a full diagnostic analysis of the company, analyse the results and implement any recommendations before contemplating any additional interventions (McAleenan and McAleenan, 2014). Within this realisation lies the key to the interrelationship between the projects. Originality and contributions to new knowledge as well as the interrelationships between projects are included throughout this thesis, showcasing the ongoing developmental nature of the author's work. The key originality themes discussed include:

- Dialogics and Praxis: Connecting quality and safety;

- Vision zero as it relates to construction safety;
- Technological and intellectual capacity to deliver vision zero;
- Prevention through Design (PtD);
- Safe to start, safe to execute and safe to finish; and
- Competent to become competent.

The specific details on how each of the key themes contributed to originality of thought and the industry impact are presented in Chapter 2. Thereafter follows specific discussions on and relevant examples of originality within the projects outputs chapters; Chapter 4 and Chapter 5. A final critical reflection on the efficacy of the projects in the achievement of their overall aims is addressed in Chapter 6, the concluding chapter.

## 1.5 Projects Outputs

Figures 1.1 and 1.2 show the development of and connections in the exemplar projects. This is followed by Table 1.1, which gives a breakdown of exemplar projects outputs in a chronological order, indicating the interrelationship between the projects and the original outputs through the years.

Figure 1.1: OAC Development and Connections.

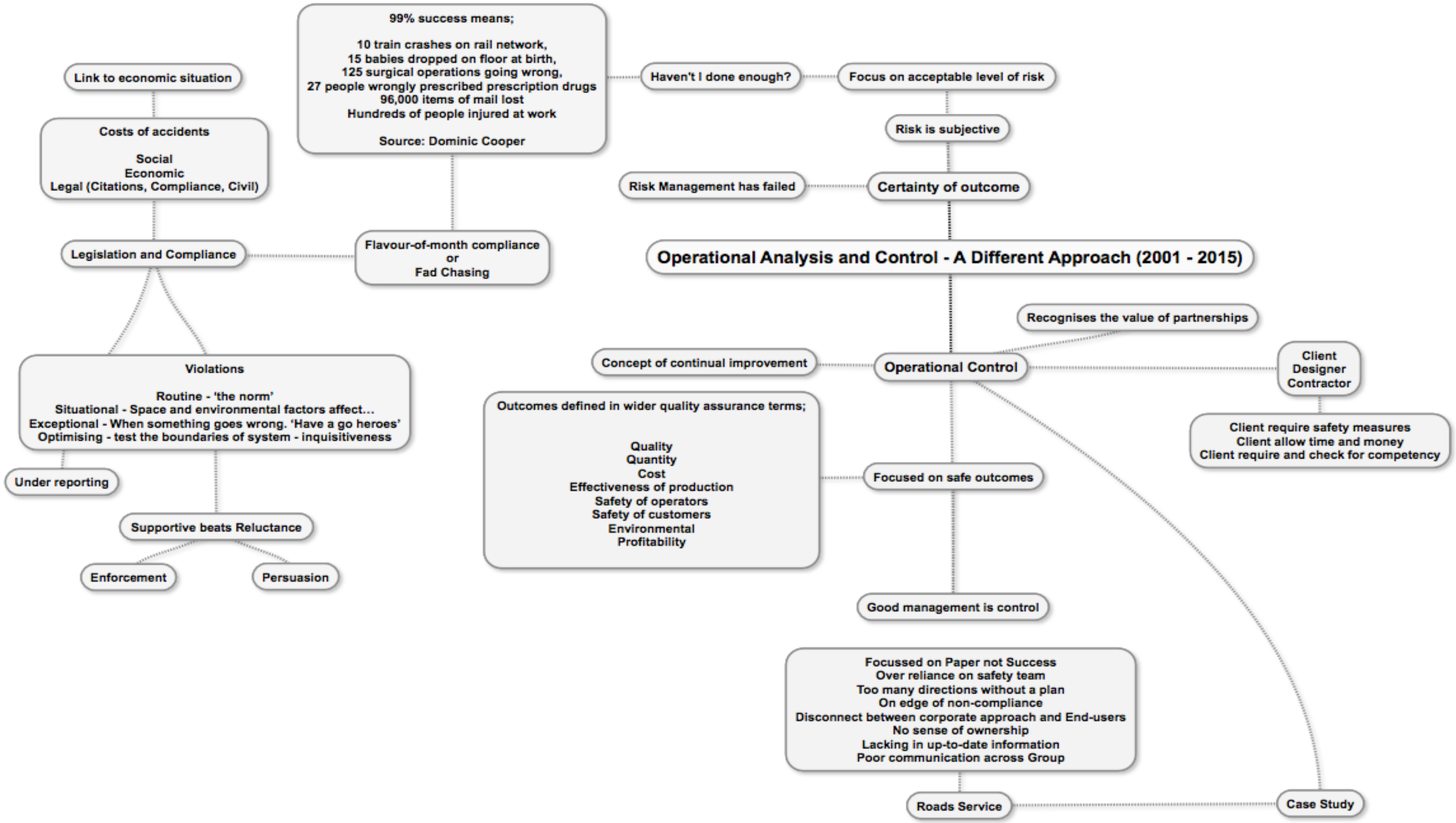

Figure 1.2: PtD Development and Connections.

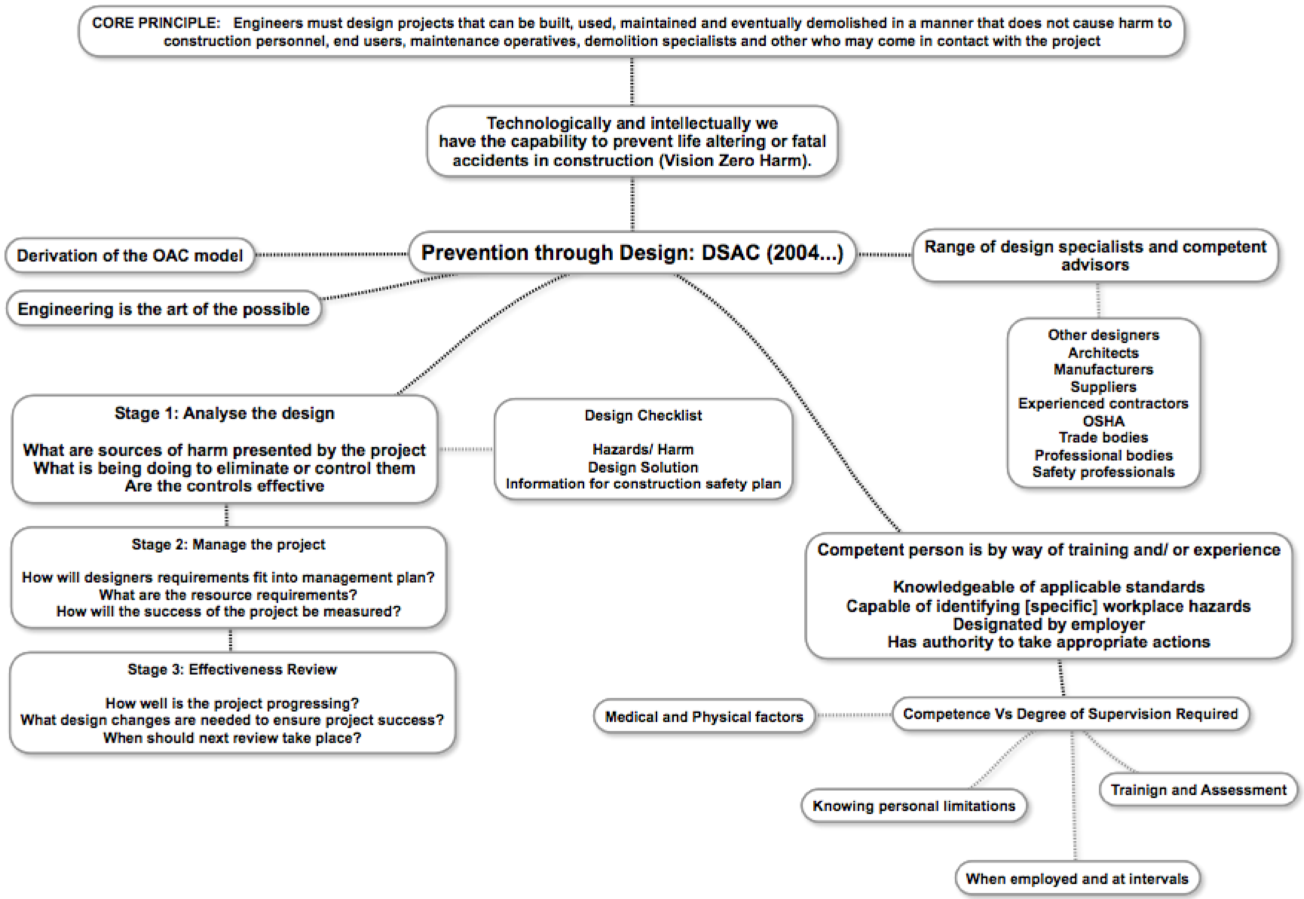

Table 1.2: Exemplar Projects Timeline and Interrelationships.

| Year | Main Outputs | | | Exemplar Projects | |
|---|---|---|---|---|---|
| | **Papers** | **Books** | **Other** | **OAC** | **PtD** |
| | | | CD ROM: Confined Spaces Expert | OAC | |
| 1999 | | | IOSH/ Zurich Municipal Supreme Safety Award. | OAC | |
| 2001 | Dynamic Safety Management in the Construction industry | | | OAC | |
| 2001 | | | NI Safety Group/ National Irish Safety Organisation Occupational Safety Award | OAC | |
| 2002 | A Different Approach – Operational Analysis and Control | | | OAC | |
| | | | Prevention through Design Training Manuals | | PtD |
| 2002/ 07 | | | OAC related websites | OAC | |
| 2004 | Safety in Design – A Risk Assessment Approach | | | | PtD |
| 2004 | | | Protocols for Low Voltage Working, Temporary Traffic Management, Contractors' Relationships Protocol, and Manual Handling of Kerbs. | OAC | PtD |
| 2004 | Highway Work Zones – A Safe Method of Working | | | OAC | PtD |
| 2004 | Design Safety Analysis and Control - Explained | | | | PtD |
| 2005 | Prevention – A Universal Responsibility | | | OAC | PtD |
| 2006 | | | ISSA Imhotep Award for Good Innovative Prevention Practices in the Construction Industry. | OAC | PTD |

Table 1.2: Exemplar Projects Timeline and Interrelationships (cont'd).

| Year | Main Outputs | | | Exemplar Projects | |
|---|---|---|---|---|---|
| | **Papers** | **Books/ Chapters** | **Other** | **OAC** | **PtD** |
| 2006 | | | Operation Analysis and Control – Poster | OAC | |
| 2006 | | | OAC related databases | OAC | |
| 2007 | Competence: Redefining the Matrix of Authority | | | OAC | PtD |
| 2009 | An Exploration of Structured and Flexible Approaches to Recognising Engineering Competence | | | | PtD |
| 2010 | | ICE Manual of Health and Safety in Construction (1st Edition) | | OAC | PtD |
| 2010 | Calculating Your Flight Distance – the Evolution of the Competent Company | | | OAC | |
| 2011 | Safety: Turning the Event into a Process: 15 years on. | | | OAC | |
| 2011 | | | Methodology for the Evaluation of Qualitative Factors in Safety Culture: Poster | OAC | PtD |
| 2011 | Enhancing Ethical Reasoning in Design Education | | | | PtD |
| 2012 | | Managing Safety in Construction: Nuclear New Build | | OAC | PtD |
| 2013 | | Health and Safety for Construction Professionals | | OAC | PtD |
| 2015 | | ICE Manual of Health and Safety in Construction (2nd Edition) | | OAC | PtD |
| 2015 | | | Safety Engineering and Disaster Management Degree Programme. | | PtD |
| 2015 | Revisiting Lorent | | | | PtD |

# Chapter 2. Key Originality Themes

## 2.1 Introduction to key originality themes

This chapter discusses where the author's work has demonstrated the creation and interpretation of new knowledge, through original research and advanced scholarship. This and the subsequent chapters present a critical reflection of the significance the work has made to the academic field.

## 2.2 Dialogics and Praxis: Connecting quality and safety

The author explored the relevance of the connection between quality management and safety management though the dialogics lens; that is how the past is altered by the present as much as the present is directed by the past, and though praxis; that is recognising the need to go beyond interpreting the world in various ways to the point where you change it. In examining the work of Aristotle (cited in Illich, 1971), Marx (1845), Freire (1970), Illich (1971) and Crosby (1979) the author made a distinction between the essential elements that allowed a thorough comparison of quality and safety, establishing whether a robust and practical link existed. It is worth noting that in late 1990s into the early 2000s, all across Europe the quality/ safety link was uncommon.

In a survey, carried out in 2000 by the European Agency for Safety and Health at Work[3] (EASHW) into the state of occupational safety and health across EU Member States (EASHW, 2000) there was no mention of quality management and interestingly very little reference to safety management either. The EASHW 2000 Annual Report (EASHW, 2001) discussed quality but in relation to the quality of service provided, not quality management. A case for making the link and for developing an appropriate model had to be compelling and suitable projects to prove the model's worth found. Are quality management and quality processes a modern phenomenon, the product of management strategists in the post world war II industrialization era or are they an innate construct of a longer held 'weltanschauung' (or world view), manifesting in various iterations to address

[3] European Agency for Safety and Health at Work (EASHW) later became EUOSHA.

specific societal needs? Citing Aristotle, Illich (1971) ascribes that Aristotle revealed ‘making’ and ‘acting’ to be so different that one never includes the other. Modern technology, Illich (1971) argued, had increased man’s ability to relinquish the "making" of things to the machine, and in so doing had increased the time available for "acting" and as a consequence developing systemic educational, quality-centric approaches to action.

The term used by Aristotle for ‘making’ was "poesis," and the word he employed for ‘doing’ was "praxis." And it is this term ‘praxis’ associated with ‘doing’ (or action) that formed the basis for the development of the advanced social activist tool; the praxis model, predominant in the strategic thinking of 20$^{th}$ century socially responsible educationalists (Freire, 1970; 1973). The praxis model, considered carefully and modified appropriately became the foundation from which OAC emerged.

## 2.3 Vision Zero as it relates to construction safety

The concept of vision zero is heralded as emanating in 1997, with Sweden’s Vision Zero Initiative [VZI] (Vision Zero Initiative, 2015). The proposition being that accidents do not happen in isolation; they are not without human impact, neither in their cause nor in their effect. Do accidents happen to people or do people cause accidents? Either way human factors need to be taken into account when designing ‘vision zero’ safe systems. Workers are not just pawns on someone’s chessboard to be sacrificed for the greater good. Rather the greater good recognises that workers are indeed major players in the game, with all the skills and autonomy needed to deliver a safe and healthy product without a negative impact on their wellbeing. If only they were allowed to do so. Fromm (1947) contended that what was good for the individual must also, of necessity, be good for humanity. Sweden’s VZI, with it specific road safety focus has a ‘No loss of life is acceptable’ approach (Vision Zero Initiative, 2015) which sums up the challenge.

What was clear then as it is now was that even in the area of road safety, driver education, enforcement and car design and manufacture were critical aspects of the initiative. In considering the societal impact infrastructure design and development has civil engineers can positively impact on their environment, while meeting their social responsibility, through the elimination of many of the obstacles to vision zero. This is a core tenet of the engineers' code of ethics and a central theme in the Institution of Civil Engineer's Royal Charter (ICE, 2014).

Even if the challenge for engineers wasn't immediately recognised vision zero brought with it the potential for prevention through design to become the engineers' mantra. Through this developing prevention through design mindset designers can have it within their gift to deliver, at the very least zero fatalities and zero life changing incidents up to and including the very best situation of total zero harm.

In today's internet-age it is hard to recall a time when information sharing wasn't universal and virtually instantaneous. In the late 1990s the spread of information sharing was much slower and more niche focused, consequently rapid growth in the spread of knowledge and in the opportunity for other communities to react to and join in with initiatives was much more limited. That said, there is every reason to believe that whenever conditions are right similar ideas, from other thinkers around the world, can emerge synchronously. Where the vision zero initiative in Sweden (Vision Zero Initiative, 2015) related solely to road safety the author's proposed vision zero harm approach across all facets of the construction industry (McAleenan and McAleenan, 1999) was an original idea, leading directly to the equally original idea of Prevention through Design (McAleenan and McAleenan, 2004; Tymvios et al, 2015).

## 2.4 Technological and intellectual capacity to deliver vision zero

Delivering safety management as a systems approach, akin to quality management was setting a new theoretical foundation upon which future health and safety education, training and performance was to be built. The author's Operation Analysis and Control paradigm (McAleenan and McAleenan, 2001; 2002) put workers at the heart of safety management, not as an adjunct as was implied in the accepted norm at the time. *"I*[t] *should be the primary role of Risk Management to aim for complete control of risk"* (Subject C, from online critical discourse 2001, Appendix 4). The production and proving of the OAC model (McAleenan and McAleenan, 2001; 2002) and the educational work associated with developing Prevention through Design (McAleenan and McAleenan, 2001; 2002; Tymvios et al, 2015) learning and teaching packages are examples of outputs from the author's original work in safety, health and wellbeing. The work began in the late 1990s to address a specific problem with safety and health management arrangements in the construction/ civil engineering industry. At the time and still today there were issues with eliminating fatal incidents and significantly reducing or eliminating any and all sources of harm in the industry. The initial concept derived by the author (McAleenan and McAleenan, 1999) and held to be true throughout the development and delivery of a range of workplace safety, health and wellbeing related projects in the intervening years was that:

> "Technologically and intellectually we have it within our capability to [deliver vision zero] prevent fatal accidents from ever occurring."

Workers need to be at the heart of safety management not external agents affected by its consequences and with acceptance of competence and agency (active participation) comes cognition; the ability for workers to challenge their historical and social situation. Systems function as a whole and they cannot nor should they be analysed in terms of their individual components. Kincheloe (1991) referred to this as devoting *"…attention to issues of human dignity, freedom, authority and social responsibility*". Where workers' critical conscientiousness is recognised concerns with problem solving would transcend towards a determination of the aetiology of the problem; the reasons behind how things are. Introducing praxis, dialogic and critical reflection into safety management was a unique and unusual approach to adopt where engineers, construction managers and battle-hardened clients were concerned. Linguistic analysis has never been a critical engineering skill, but in reshaping the world of safe and healthy working it is a necessary approach in order to firstly understand the unconscious rules and processes that tend to govern us and ultimately to refocus and present a new and original paradigm; OAC (McAleenan and McAleenan, 2001; 2002). This principled approach had potential to achieve significant improvements in safety and health performance, moving the industry away from accepting that accidents happen towards the belief that zero harm is a very real and achievable objective. This was the cornerstone of all that had emerged from the author's work from that point onwards. Indeed, not only was critical reflection an unusual approach but vision zero in the construction industry of the late 1990s was uncommon.

## 2.5 Prevention through design (PtD)

In 2001 at a joint Health and Safety Executive/ Quarry Products Association (NI) seminar the author's first iteration of PtD principle was made public; "*Design it, Build it; Maintain it; and Demolish it taking full account of the safety of the construction worker, the end user and anyone else who may be affected*" (McAleenan 2001). At the 2004 American Society of Safety Engineers (ASSE) professional development conference the author presented and discussed the concept (McAleenan and McAleenan, 2004). The author further made this original PtD thought known publically, in the UK at a 2005 ICE CDM conference and privately (at the same event) to the HSE inspector charged with writing the revision consultation document for the CDM 2007 Regulations. During the consultation process the author proposed that the PtD principle become part of the new regulations and/ or Approved Code of Practice (McAleenan and McAleenan 2005[4]). In the search for a new approach to construction safety management the author conducted a critical evaluation of that which is required of practicing

[4] A version of this premise was then published in the CDM Approved Code of Practice of 2007, showing how the author's ideas are reflected in the UK legislative requirements *"...designers' responsibilities extend beyond the construction phase of a project. They also need to consider the health and safety of those who will maintain, repair, clean, refurbish and eventually remove or demolish all or part of a structure as well as the health and safety of users of workplaces...*"

professional engineers in the Institution of Civil Engineer's (ICE) Royal Charter (ICE, 2014) and that which is defined in UK Standard for Professional Engineering Competence (UK SPEC) "*Prepare, present and agree design recommendations, with appropriate analysis of risk, and taking account of cost, quality, safety, reliability…*" (Engineering Council, 2014). Although updated to 2014 versions the requirements to deliver designs that can be built, used, maintained and eventually demolished without causing harm to workers or users (aka prevention through design) could have been inferred from text that dates back to 1828 when the ICE's Royal Charter was first granted "*All members shall have full regard for the public interest, particularly in relation to matters of health and safety, and in relation to the well-being of future generations*" (ICE, 2014). The current state of safety, health and wellbeing in construction would suggest that the author's core premise was either true but was not being fully followed or that it was untrue and thus the professional bodies were failing in the exercise of their Charter responsibilities.

The success[5] behind any construction project begins with a Client's willingness to commission a project that will bear the test of time and stand acknowledged by present and future generations as a symbol of excellence in the built environment and that excellence must embrace safety health and wellbeing of all people impacted by the design and presence of the structure. The translation of the Client's desire into a finished project falls to designers (engineers, architects etc.), constructors and appropriate advisors. What role then for regulation? 1994 saw the introduction of the first of the Construction (Design and Management) Regulations (CDM), the UK's response to the EU Directive 92/57/EEC temporary

[5] The measure of success transcends cost, quality and time. Any human loss negates project success.

or mobile construction sites (EUOSHA, 2015). In a response to the HSE consultation into the revision of the CDM Regulations, where HSE had indicated,

> *"...*[that] *designers are in a unique position to eliminate or reduce the risks that arise during construction work and have a key role to play in the design and management of construction projects"*

the author responded suggesting that in their update to CDM that HSE should fully embrace the prevention through design principles; defined by the author as:

> "*Construction projects must be designed to be built, used, maintained and eventually demolished in a manner that does not cause harm to construction personnel, end users, maintenance operatives, demolition specialists, and others who may come into contact with the project.*"
>
> (McAleenan and McAleenan, 2005)

The author's original PtD definition (McAleenan, 2001) was a progression from the earlier OAC model developments, of the late 1990s, leading to the development of the Design Safety Analysis and Control model (McAleenan and McAleenan, 2004) and the Safe to Start checklist process, presented to World Congress on Safety and Health, 2011. Various alternative wording existed, such as Safety in Design (SiD) and Safety through Design (StD) have been used as descriptors of the same PtD ideal. On the interface between clients, designer, engineer and contractor PtD requires the acceptance of project objectives that include tasks or activities being completed on time and in a manner that does not cause harm to the employees, customers, other non-employees, or the company. This approach recognised that some hazards can be eliminated or contained through good engineering design solutions and others, inherent in the process, have to be safely worked around. In all cases it is essential to identify at the earliest opportunity what hazards exist, the harm that can result and how they might materialise. Fundamentally this necessitated a full analysis of the design safety issues, followed by the development of appropriate controls to ensure that work operations during the construction phase proceeded in a manner that makes certain that people, plant and property are protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced. The author moved to align PtD thinking with inherently safe design thinking (Kletz 1978); the idea being that it is the designers' approach rather than a specific set of tools and technologies that determines whether safety in design is achievable. The design safety analysis and control (DSAC) approach (McAleenan and McAleenan, 2004), a derivative of the Operation Analysis and Control (OAC) model (McAleenan and McAleenan, 2001; 2002) integrated all aspects of the construction design project process. Underpinning this approach was the absolute control of all stages of the process. The DSAC model (McAleenan and McAleenan, 2004) was apt for ensuring that the requirements of EC Directive 92/57/EEC (EU OSHA, 1992) could be met, with particular reference to project preparation.

2.6 Safe to start, safe to execute and safe to finish

From the earlier days of the Health and Safety at Work etc. Act 1974 (OPSI, 1974) an often misinterpreted approach to safety was that risk was inherent and that consequently accidents were somehow inevitable. However, to think and to act in a manner that suggested this was true was a serious disservice to the workers who rely upon best advice to complete their work without hurt or ill health. Safe design applies to the design of a work operation as much as it does to the design of a structure. What happened when the EU inspired management regulations were enacted in the 1990's was that a focus was put on risk assessment and the consequential misinterpretations and misinformation (Lofstedt, 2011) led to a plethora of written risk assessment and the mistaken belief that risk, as it applied to workplace safety, health and wellbeing was something that could be managed. The author's view was that projects needed to be managed with safety and quality on an equal footing. If the approach to quality targeted zero defects then, by extension, zero defects implied zero harm. That wasn't a part of management thinking in the late 1990s, until the author introduced it into the Roads Service. McAleenan and Orr (1999) asserted:

*"…Safety cannot be treated as an event or a series of single events spread across the working year. It is a thought process within each of us that can and should be reinforced through the production of original and thought provoking material…'.*

Following conversations at the 2001 ISSA Construction Safety Symposium in Paris, the author aligned the OAC model with the USA, National Institution for Occupational Safety and Health (NIOSH) thinking that accidents are 'preventable injuries', (McAleenan and McAleenan, 2001). This approach, taken in harmony with the views from education, quality and indeed value engineering reinforced the true value of introducing 'critical reflection' as a central and unique aspect of the thought process endemic in the praxis approach to workplace safety, health and wellbeing. Safe to start, safe to execute and safe to finish, discussed by the author at World Congress (McAleenan and McAleenan, 2011) was the outworking of the interrelationship between the two central and original ideas of vision zero harm and PtD.

## 2.7 Competent to become competent

One further issue that was necessary to ensure that the OAC model (McAleenan and McAleenan, 2001; 2002) would be successful thus ensuring that the worker-centric approach would be properly embedded was to consider how competence was defined. In the traditional thinking competence was defined, as having skills, knowledge and experience. But that was a restrictive definition that ignored some fundamental requirements; namely resources and authority to make decisions. The author explored this (McAleenan and McAleenan, 2007; 2008), addressing the neutering effect of excluding the worker from safety decisions. Garavan (1997) noted that the Irish courts[6] had also looked at the matter as far back as 1977,

[6] Dalton v Frendo (1977), Irish Supreme Court Case, discussed in pps. 69-74, Garavan (1997)

where the Supreme Court, commenting on the qualities of a competent person, held that:

> “[having] *due regard to the age, skill and experience of a worker, he or she will know the hazards associated with their work and be able to apply the controls necessary to prevent harm*”

Thus it was established that the ability to work safely is an integral aspect of competence and needs to be recognised as such in the execution of safe systems of working. There was widespread agreement that a competent worker is skilled, authoritative and in control of his work (ISSA, 2003; ILO, 2008; ANSI/AIHA, 2005; McAleenan and McAleenan, 2008; Ayers and McAleenan, 2008).

At CIB W099 in 2009 (McAleenan and McAleenan, 2009) the author introduced the concept of competent to become competent, where workers are recognised as having the capability to continuously extend the boundaries of their knowledge.

The individual stands continuously as a contradiction in and off himself, both competent and not competent at the same time. At that point he may choose to remain sufficiently competent to maintain the status quo or he may wish to progress, broadening his experiences, acting on ever increasing challenges until he achieves excellence. Reaching the point where is he able to become competent in different and wider areas is the point where he is competent to become competent; capable of continuously extending the boundaries of his knowledge. Much in the same way as the OAC approach was about continuously reviewing and revising safety management in the organisation. The competent to become competent idea when aligned with the initial ideal of continuously challenging and improving upon the approaches to safety health and wellbeing completed the circle of originality that would see OAC, as a paradigm shift for construction safety, health and wellbeing mature.

# Chapter 3. Methodology: A Critical Reflection

3.1 Applying systems thinking to safety, health and wellbeing

A discussion on research methods and approaches discussed in the books, papers and chapters [outputs] is continued in project specific chapters, as appropriate, where the aim, methodologies chosen and the conclusions reached is discussed. The research and related outputs demonstrated how the adaptation of a systems thinking approach could deliver significant improvements in workplace safety, health and wellbeing, while advancing the inherently safe[r] design debate within the civil engineering profession. The research methods followed in the development of the projects discussed in this thesis are varied and perhaps less than the conventional norm experienced in academic circles, however the majority of the work described is practice based. A retrospective critical analysis of the methods followed is presented below.

Every research project begins with a question, often that question is 'what if'; "what if there was a better way to…?" The author's research was fuelled with a desire to critique that which existed as the accepted norm, to develop theories and practices that could give new insights. In that journey the author looked beyond traditional boundaries and brought alternative socially responsible educators and their educational tools to bear on a predominantly conservative industry, that was civil engineering and construction. The primary objective in the author's work was to develop a new way of thinking in the field of occupational safety and health, with particular emphasis how workers could regain control of their safety, their learning, and their destiny. Semler (2003) instigator of a successful and revolutionary democratic workforce in Brazil in the 1980s held that "*organizations must help workers indulge their interests and talents by seeking the same professional growth and satisfaction as musicians*". In order to achieve true workers involvement to the level suggested by Semler (2003) it was necessary to demonstrate how the application of dialogics and praxis develops critical conscientiousness (Freire 1970). In choosing and focussing on praxis as the guiding way forward in the delivery of a new paradigm in safety management the author is inclined towards Freire's concern with action that was both informed and linked to social values (Smith, 1997; 2002). Accepting that individuals have the intellectual capacity to know how to safely control their own workplace operations and that the development of that capacity is within an informed and socially responsible educational route.

The focus of the author's research and the portfolio presented centres on systems approach to management, specifically in safety, health and environmental fields, with an emphasis on linkages to lessons learnt from quality management. The majority of the work critiqued in this thesis has a professional practice basis. The author was, in the early days of the research, based entirely in professional practice, with the occasional venture into the academic world, however it is appropriate in this analysis to describe how the exemplar projects as described have developed within an academic framework. That said the research methodology most prominent would best be described as social constructivist, in so far as the creation of the model initially involved an element of linguistic analysis. For example, the discourse on risk management a failed paradigm (McAleenan and McAleenan, 2002, [Appendix 4]) explores and debunks the myths emanating from steadfast insistence that linguistic prescription take precedence over linguistic description. And in that the author's critique moves through and between these opposing views. In other words, holding the belief that language exists to serve and not to be served turns the large majority of the analysis towards the very practical aspects; dialogics and praxis.

## 3.2 Education: Value Engineering: Quality: Praxis

The author explored the work of Juran (1986), Deming (1986) and Crosby (1979), reviewing it against international quality standards to compare with the safety, health and wellbeing regulatory requirements. In addition, the author introduced the relevance of dialogics to safety, health and wellbeing; that was how the past, or our perception of the past could be altered by the present as much as the present can be directed by the past. Ultimately the exploration focused on praxis; that is recognising the need to go beyond interpreting the world in various ways to the point where you change it (Marx 1845), and that in deciding in what way the world is to be changed processes are set in motion that influence the future. Marx (1845) in Thesis III on Feuerbach explains;

> "*The coincidence of the changing of circumstances and of human activity or self-changing can be conceived and rationally understood only as revolutionary practice*".

In examining the work of Aristotle (cited in Illich 1971), Marx (1845), Freire (1970), Illich (1971), the author distinguished the critical elements that allowed for a thorough comparison between quality and safety and established that rather than just a robust and practical link existing, there is a significant step forward, in that the praxis approach to OSH management developed though this analytical interpretation introduced 'critical reflection' as a central tenet of the model. It is necessary in reviewing progress to examine the point at which you have arrived, rather than the point from which you started before determining your next action. In other words life (or the world of work) is a constantly changing paradigm with every action shifting its position, therefore to reflect and act upon the circumstances that prevailed at some fixed point, as with quality is to fail to recognise this logic. In critiquing Freire's praxis of pedagogy Pietrykowski (1996) interprets the praxis model thus; "*Problem-posing education involves a constant unveiling of reality…[it] strives for the emergence of consciousness and critical intervention…*". Freire (1970) contends that the dialogical character of education begins when the teacher asks himself what his dialogue with the student will be about. In a follow up text Freire (1973), discussing education for critical consciousness, talked about educators having to think in terms of teacher-student and student-teacher; that is, a teacher who learns and a learner who teaches as the basic roles of classroom participation. Freire (1973) also insists that educator and student are not on an equal footing, but that the educator must be humble enough to be disposed to relearn that which he/she already thinks they know, through interaction with the learner. Education as a means of social praxis promotes dialogic learning, that is it requires both interpretation of the subject and judgement of its worth and meaning. Pietrykowski (1996), citing Habermas (1979) refers to this as communicative action, the rational desire to understand one another *"…requiring that claims to truth, sincerity and legitimacy be accepted as part of the learning process*".

In a similar fashion to educational praxis models the design industry introduced value engineering, which asks how it is proposed to deliver a project and challenges the bona fides of the project, through asking why this is so. Value engineering is concerned with defining and identifying approaches that will ensure the achievement of best value solutions, executed in an organised and systematic manner to identify and eliminate any unnecessary cost. Describing the process as value management, Kelly and Male (1993); in an attempt to emphasise its broader management function, distinct from a pure technically driven solution finder refers to its capability to manage the evolution and development of a project from conception through to completion. Value engineering/ management is not, and should never be used as a cost cutting exercise neither should it be confused with a design review. It sets out to clearly define the client's strategic objectives, considering the optimum design solutions within the context of the client's business objectives and deciding which of these provides the optimum lifetime value to the client.

The final output from a value engineering/ management exercise should be a solution or a range of solutions that are technically feasible and financially viable. Such an approach is firmly rooted in the quality frameworks espoused and practiced by Crosby (1979), Deming (1986) and Juran (1986). The Chartered Quality Institute (CQI 2012) describe quality in terms of both innovation and care; innovation in respect of the product or service as well as in the management of the process and care for all of the stakeholders and the environment. CQI (2012) argues that quality is an aspect of business that needs to be managed in order to identify any associated delivery risks, put in the controls and ensure the delivery of a sustainable product or service, reflecting the nature of quality in relation to societal responsibility. Therein lies the concept of quality management, moving industry away from inspections and statistical process control. The recognised experts in the field of quality management have long established the link between properly executed quality management procedures and the delivery of a quality product and in so doing developed variations of the praxis model, initially and specifically for manufacturing and production. Crosby's (1979) belief in the achievement of zero defects, Deming's (1986) Plan, Do, Check, Act and Juran's (1986) quality trilogy.

## 3.3 Philosophy of Praxis

Gramsci, in his Prison Notebooks in the 1930s (cited in Löwy[7], 2011) used, for the first time, the expression a “philosophy of praxis”. The philosophy when practiced in workplace safety, health and wellbeing sets a standard far beyond the quality paradigm. That is that quality relied upon a rigid consistency of approach to deliver a pre-determined outcome (product or service), same way, same thing, every time. Where praxis has some similarities with Deming (1986), Juran (1986) and Crosby (1979) is in its adherence to planning and control, the essential difference, and what sets it apart is the critical reflection at each point along the way. Checking, reflecting that change has already taken place and the realising that the journey may also have changed. The rigidity within the quality models exposed their fixation with consistency of approach regardless of whether the direction was right, failing to contextualise with society other than as a commodity. Profit drove the changes and in that was the question, where did societal responsibility fit in the scheme?

Dialogics on the other hand recognised society as an integral aspect of what is produced. It is not an abstract concept, rather it established that workers analyse the impact of the work on themselves, their colleagues and called upon them to consider the wider harm the work and/ or the product might have on society. Certainly within professional engineering ethics, societal responsibility was a fundamental principle. At the extreme the munitions worker, the tobacco plantation worker or the operative on the line at the cigarette factory all have a role in analysing the degree of harm they were likely to be exposed to, but what of the harmful effects of the end product? For them harm comes in many ways and protection of their livelihood would determine the abject meaning behind decisions they would have to make. This, as presented, suggested a sense of powerlessness in the workers, until through the praxis approach the workers could grasp the opportunity to recognise and address some of the dilemmas of competing objectives (McAleenan and McAleenan, 2010). Factory or plantation

[7] Löwy (2011) was perceived by many as defining Marx as a worldview.

owners however did have a chance to explore the societal aspects of the praxis model. However, as the workers become more aware of, move toward greater understanding of and ultimately be in a position where they could take control of all their decisions; a ‘raising of consciousness’ then power could become more evenly distributed. The boss/ worker tell/ do attitudes could be eradicated from the world of work to be replaced with a more socially aware and responsible organisation; the essence of cultural maturity (McAleenan and McAleenan, 2009).

### 3.4 Safety, Health and Wellbeing - The Praxis Approach

McAleenan and McAleenan (1998), exploring the need for the industry to deal with the high degree of fatal incidents in confined spaces working began the process of modelling safety management, based on their earlier work in social action and on the well established praxis models in education, value engineering and quality. Exploring the merits of a Prevention-Appraisal-Failure (PAF), model ordinarily used to evaluate the cost of quality Juran and Gryna (1988), Crosby (1979) and McAleenan and McAleenan (2005) all assert that a higher investment in prevention will ultimately lead to reduced appraisal and failure costs. The ultimate aim being the ability to identify the optimum investment where cost of quality is at its minimum. There are as many variations in cost of quality models, as there are authors in the field, however Juran and Godfrey (1998) gave a good representation of the key points.

The close similarities between quality management and the management of safety, health and wellbeing are such that systems alignment should have been inevitable. However, while some work was starting to emerge BSI (1996), Health and Safety Executive (1997) and DNV (1997) the linkages were still only at the conceptual stage in the late 1990s. OHSAS 18001:1999 (BSI 1999), although never achieving International, European or British Standard status, remains an acceptable safety management specification[8], recognised by many countries and companies. It also

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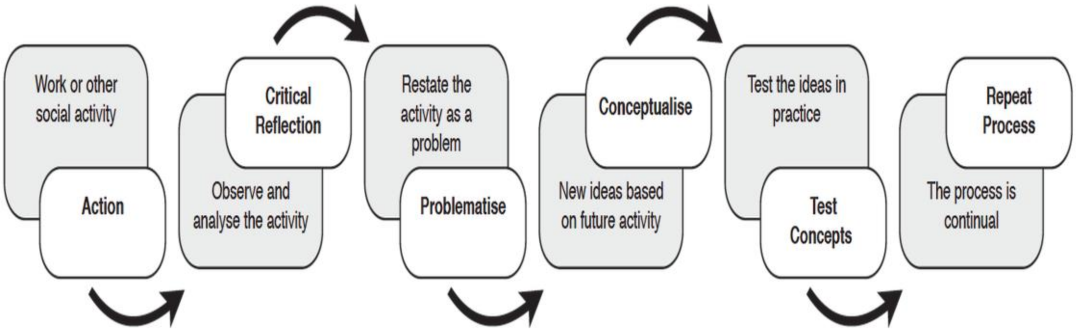
[8] In October 2016 a new safety management systems standard (ISO 45001) is expected to be launched (International Organization for Standardization, 2015)

has clear correspondence with ISO 14001 (environmental management) and ISO 9001 (quality management).

Recognising the critical integration issues Eckenfelder (1996) reported that several chief executives of the largest U.S. companies had agreed that the influence of Deming (1986) had prompted them to ask more about the process than the ‘bottom line’. However, Eckenfelder (1996) also found that while most managers knew and spoke the language of quality and translated the text to the field of occupational safety and health few appeared to understand its connotations. As a consequence, the quality and safety message still appeared to be ‘surface level’ thinking in 1990s corporate America. McAleenan and McAleenan (1998) observed that the target for quality improvements in an organisation's safety performance must be to raise the standards and to reduce workplace accidents within specified timeframes. This, they hypothesised, is achievable through the use of techniques such as; safe working procedures (akin to quality procedures), risk assessments (akin to process control), and performance measurement (akin to control of non-conformance). The cost savings, in financial and human terms, will serve to engender an enthusiasm for improvement throughout the organisation, which should spread to other aspects of the business, thereby affirming the benefit to be gained from adopting costs of quality models as a means of achieving improved safety performance. There is a paradox of having to enthuse employers to engage with safety, health and wellbeing in economic terms, which is fostered in the risk management approach (McAleenan and McAleenan, 2002).

In the development of OAC (McAleenan, 2001; 2002) the author used praxis as the defining model for safety management Praxis recognised and built upon the dialogic concept that work is both informed by and informs the actions to be taken (McAleenan and McAleenan, 2014). Through the embedding of critical reflection, problematising and conceptualising, an iterative approach, praxis allows the researcher, the practitioner and/ or the operative to explore widely and deeply the impact of and solution to any real world scenarios where harm would be present (Figure 3.1).

Figure 3.1: Praxis: Defining Model Managing Safety, Health and Wellbeing




To problematise, for instance gave the opportunity to represent the activity, once defined, as a problem that needed to be resolved. Within the construction and civil engineering field problem solving; the desire to figure things out, is an inherent trait, alongside creativity and innovation. McAleenan (2015a) suggests:

> *"Actively creative people have the ability to get to core of a problem, without becoming embroiled in the standards or the details."*

Problematising, or the use of "*creative licence*" (McAleenan, 2015b; McAleenan and Behm, 2014; McAleenan and McAleenan, 2014) allows for the potential to 'think outside the box', affording those involved in the OAC process the opportunity to consider less conventional ideas in the delivery of safe and healthy solutions. This approach, aligned with the philosophy of praxis (Gramsci, 1930 cited in Löwy, 2011) led to the question; could the gains achieved through quality management and the respect it had got at Boardroom level be transferred to the management of safety, health and wellbeing with comparable degrees of success? For an acceptable answer there was needed to be an acknowledgement of and a nurturing of a vision zero approach as an inevitable consequence of the development of the management process for workplace safety health and wellbeing. An idea with strong affinity to Crosby's (1979) zero defects focus and one that was further endorsed in the work of Flechler (2011) and Kellner (2011), presented at the World Congress on Safety and Health at Work.

Success required leadership with a focus on a praxis approach to problematising and to solution delivery, resulting in the development of positive and dynamic management tools, accessible by and amenable to everyone in the workforce. McAleenan and McAleenan (1999) introduced the premise, "..*technologically and* *intellectually we have it within our capability to prevent fatal accidents from ever occurring in confined spaces*" before going on to explore the vision zero concept. The theme strongly running through the observations recounted in McAleenan and McAleenan (1999) further validated the author's hypothesis (McAleenan 1998) that quality approaches and safety approaches needed to merge. This in turn would address causal factors and solutions that had a strong business focus. This kind of thinking was fundamentally an unfamiliar concept for UK safety professionals to grasp in the late 1990s, although Ibbetson's work in Canada, at the same time, was introducing similar ideas from a communications perspective (Ibbetson, 1998).

### 3.5 Critical theory, critical consciousness and linguistic analysis

As the work progressed and the ideas were developing the author's next step was to delve more deeply into the language of safety, the ideological barriers being created through the misuse and misinterpretation that for the industry and the profession had become commonplace. In a very real sense the approach was to get behind the language in use to reveal the true intent and through a process of deconstruction and reconstruction of the language help the industry redefine its purpose. Critical theory largely used in philosophy and social science was an appropriate avenue for the author's work as the OAC model was developing to its full potential as much as it was an appropriate method to employ in redefining the scholarly work within the emerging PtD education and training programme. The work of Sherratt (2012), described as social constructivism is the closest alignment in construction safety, health and wellbeing research. Albeit that where social constructivism might go far enough to identify the ideologies existing within the industry, critical theory goes further with deeper analysis into why the ideologies exist and where they might lead before proposing a way forward. The critical theory approach does not seek to change ideologies, but to understand from where they have come and in presenting alternative workplace safety, health and wellbeing solutions allow the audience to make the transition through informed choice. This was behind the conscientization (Freire 1970) or critical consciousness approach to the development of both OAC and the PtD education and instruction programmes. Freire's use of the term critical consciousness rested in the idea of a quality that is essential to one's personal and collective identity while Mustakova-Possardt (2003) suggests that Freire’s (1970) critical conscientiousness approach demands “*critical thinking, an understanding of causality, a grasp of the processes of history, and the ability to translate thought into action*”. It was that which the author sought to achieve in construction workers, designers and the safety practitioner community. Related to all of this is critical pedagogy, involving the process of unlearning, relearning through critical analysis, reflection, evaluation and synthesis and as a consequence deconstructing and reconstructing the language of safety.

In the conduct of the research and development for both of the exemplar projects the extent of linguistic analysis had a focus on specific terms and terminology. This was not so much an academic exercise in exposing the wrongness of those using the language in its common everyday use, for in the early days and in the first iterations of OAC the author too had used the same language. Rather the purpose was to expose the consequences of the incorrect use of the language, no matter how innocent the misuse was and through critical consciousness approach allow practitioners to achieve a deeper understanding of the world, through exposure to the inherent contradictions in the then widely accepted approach to safety, health and wellbeing.

What became clear in the early 2000s (McAleenan and McAleenan 2001, 2002 and 2004) was that the ideological and firmly routed stance adopted by the majority of the safety and health professionals with regards to ‘risk management’ was in fact a barrier to achieving the zero harm objective and sat at odds with the OAC model. Not that it was ever felt that the intentions of practitioners was to do harm, rather the inappropriate use of language was creating a false belief that vision zero was a dream too far away from reality to ever come true, supported in IOSH (2004), McAleenan and McAleenan (2005), McAleenan and McAleenan (2007), McAleenan and McAleenan (2008), Ayers and McAleenan (2008). Viner’s work, cited in Ayers (2010) supports the notion that “*…there is a body of anecdotal and academic evidence, which supports the idea that people at risk often have very limited perception about what can be changed in their work environment to improve their health and safety*”. What had surfaced in the author’s own critical reflection of the developing OAC model was a well-defined need to deconstruct the existing language and reconstruct it with a more positive, forward thinking outlook.

While critiquing the term ‘risk management’, in an effort to present an alternative way of thinking, the primary argument was one of the conflating of two mutually exclusive words, ‘risk’ meaning chance and management meaning to ‘control’. The descriptive grammarian would accept that the meaning and intent behind the term was sufficiently clear and consequently the term could stand in its common use, whereas the prescriptive grammarian approach would be to recognise the fatal flaw inherent in the conflation thereby rendering the term inappropriate at the very least. However any critical evaluation of the language of safety cannot be a purely academic exercise, rather in the highlighting of such anomalies in the language the purpose was to explore the very real possibility that critical conscientiousness can be wanting and consequently injuries might prevail. To simply look at each word in isolation and critique it would have been a superficial analysis, since there was more behind the emergence of the term ‘risk management’ in the field of workplace safety health and wellbeing. The introduction of human loss into a field where prioritising loss control is its primary function is an objectionable act in as much as worker’s harm becomes a tradable commodity in an ever-constant resources struggle. The safety professional’s desire to gain influence at Boardroom level was a critical factor in their adoption of quasi-business vernacular. Supplanting ‘safety management’ (the correct term) with ‘risk management’ may have appeared innocent enough, after all safety people talk about risk too. The developing role of the safety professional, defined in the new (EU inspired) regulations in the 1990s [another misinterpretation][9] was to manage. Put the terms together and you have the key to

[9] The requirement in The Management of Health and Safety at Work Regulations 1999 [Regulation 7] are that “*Every employer shall, subject to paragraphs (6) and (7), appoint one or more competent persons to assist him in undertaking the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions…*”. Competent person is not necessarily the company safety person, since competent assistance may come more appropriately from an expert in a very specific field; for example, a structural engineer or a geotechnical engineer, expertise beyond that of the generalist safety and health practitioner (McAleenan and McAleenan, 2004).

the Boardroom.

However, without critical reflection there was a failure to understand that ‘risk management’ was about insurance and financial loss control, not human loss.

In furtherance of the critical theory approach and staying with the linguistic challenges there was the question of whether sociolinguistics as opposed to the sociology of language was most applicable; the former exploring the effect society has on the language and the latter examining the effect that language has on society. Citing Gergen and Gergen (2004) and Crowther and Green (2006), Sherratt (2012) indicated that “*social constructionism sees the world as socially constructed by the people within it through their everyday interactions and practices*” yet in her discourse analysis Sherratt (2012) found that every day language of safety often still boils down to artefacts, rules and enforcement. None of which are overly helpful in engaging workers in the process of construction safety management. The debate clearly needs more time to run and/ or more actively engaged players. The critical evaluation of the language in use at the time the OAC and the PtD education and instruction projects were emerging and its effects had its roots in pragmatism. In as much as the words, their meanings and their use must have a clear context and in this regard an appropriate audience.

The engaging of workers at every appropriate level was fundamental to success of any management system since ‘buy in’ comes more readily when the persons concerned sees the need and are involved in creating the solutions. The total involvement of the worker was fundamental, not only in social wellbeing context but in the sense of being an integral aspect of the business. Semler (2003) asserted; “*Organizations must help workers indulge their interests and talents*” and went on to say, “*By letting people off the hook of grand policies, procedures and rules, we release them to be accountable…*”. Famed for his radical views on developing his company Semler (1993) believed in relinquishing central control to the workers and in providing information and resources that allowed workers autonomy in the delivery of product. Robens (1972) indicated that *“...must be able to participate fully in the making and monitoring of arrangements for safety and health at their place of work...*” a notion cited in and explored further in McAleenan and McAleenan (2011) where it is argued that the unnecessary influences of 3rd parties (safety advisory officers) neuter the competence of workers who should otherwise be fully engaged in the process. Ayers (2011) explored this more deeply, arguing that "*the legislative requirement to consult does not in itself guarantee the quality, richness, depth*" or indeed existence of true worker involvement in active safety management.

# Chapter 4. Project 1: The Operation Analysis and Control Model

## 4.1 Aim and Objectives for the OAC Project

Aim: To demonstrate how the application of dialogics develops worker's critical conscientiousness, aiding the intellectual capacity to know how to safely control workplace operations.

Objective 1: Development a strategic safety, health and wellbeing (OAC) model focused on operational control across different workplace activities.

Objective 2: Redefine the competence required to execute the OAC model.

Objective 3: Test the reliability, validity of the OAC model.

Objective 4: Measure the relevance and impact of the application of the OAC model.

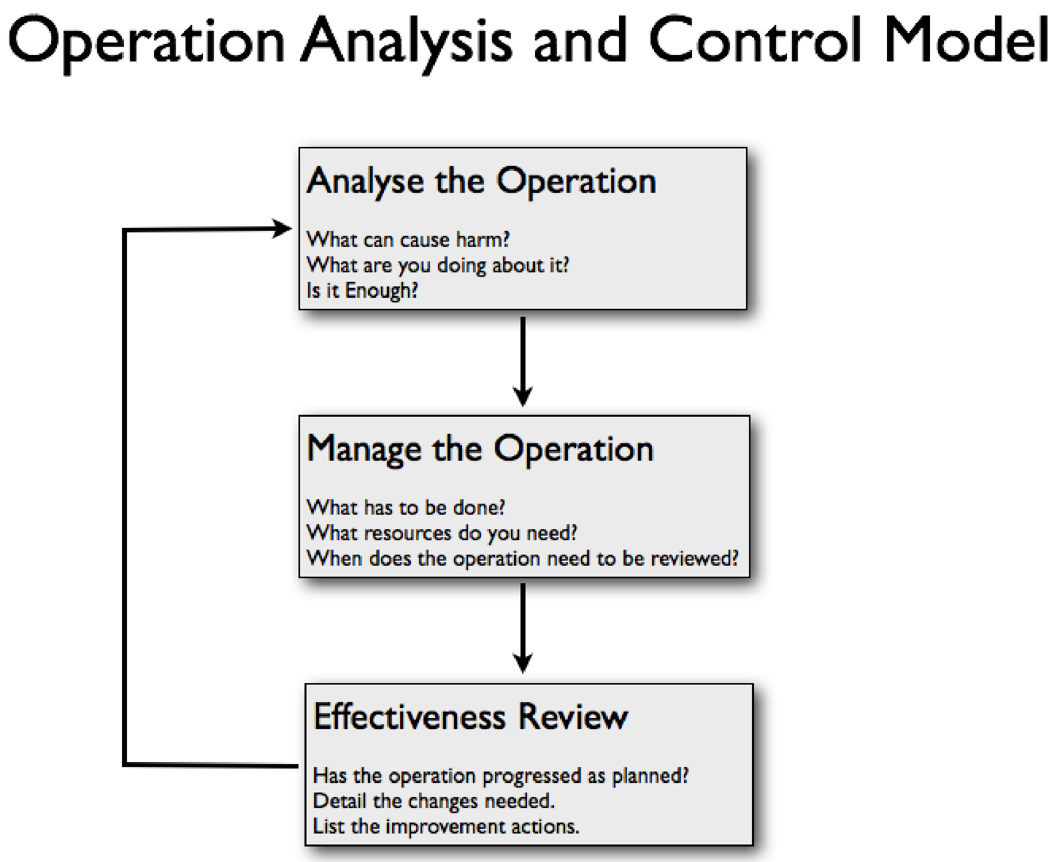
## 4.2 Motivation for the development of OAC

If quality and safety are inextricably linked, McAleenan (1998), McAleenan and Orr (1999), McAleenan and McAleenan (2002), McAleenan and McAleenan 2005 and Gunning and McAleenan (2010) what then are the consequences for hazard control in an enlightened and progressive construction company? That is to say one that seeks to go beyond legal compliance, holding to the prevention/ vision zero beliefs espoused in the Seoul Declaration (ILO 2008). The Seoul Declaration (ILO 2008) added further weight to the discourse when it stated "...the right to a safe workplace should be recognised as a fundamental human right", making worker safety and health a 'rights' issue linking it firmly with the United Nations Declaration on Human Rights; UDHR 50 (1998), McAleenan and McAleenan (2005).

The successful implementation of the OAC model into the workplace required control, of the task or the work operation, not the worker (McAleenan and McAleenan 2010). Truly successful implementation will be brought about when the worker has the autonomy to control his own work operation, equipped with the necessary competence, resources and authority (McAleenan and McAleenan, 2007; 2008). This attitude gave the worker an ability to read a situation, establish the sources of harm, identify the appropriate controls and ask the 'what if' questions.

Project 1, the development of the OAC model (Figure 4.1) for safety, health and wellbeing (McAleenan, 2001; 2002), took full cognisance of the quality into safety ideas that were emerging in the late 1990s. Although still in their infancy there was a need to critically reflect upon the established order, since the accident and ill-health rates were not decreasing as they should have (Health and Safety Executive 2015a and 2015b). The nature and type of control and the merits of operation control as compared to strategic control models; focused on the now, addressing the internal factors and guided by external factors would deliver a model that straddled both the operational and strategic perspectives thereby ensuring a worker-centric, business focused approach to managing safety, health and wellbeing.

Figure 4.1: Operation Analysis and Control Model



Defining a new paradigm for operation analysis and control, the objective being to ‘tap into’ the quality agenda and find common grounds where safety and quality become intertwined and an integral aspect of how business gets done. The true quality/ safety mix of systems development has workers at its heart with management fully supporting its delivery. A successful approach will see a worker driven collaboration with management that delivers real safety improvements across the whole of the workplace. Further embodiment of the quality/ safety systems approach should extend to designers of the management systems and procedures as well as the technical/ engineering designs of structures. In this strategy healthy and safe by design had two aspects to it. The first being the design of structures, plant and substances and in that regard the following would be considered essential:

- A thorough knowledge of the design processes and principles, together with;
- A sound knowledge of the means of production (or construction);
- Sound knowledge of how the product/ structure is to be used; and
- Knowledge of eventual disposal/ demolition methods.

In that way the designer fulfils a professional and ethical responsibility to provide a safe product/ structure design that will not present harm to anyone using or affected by its use at any stage in the life-cycle. In the second aspect healthy and safe by design referred to designing work processes and systems of work, and as such does not specifically refer to the design professional. Design in this regard relied upon those most familiar with and most affected by the work processes. The list of people involved would vary and had to be specific to the work process. The primary requirement for inclusion to the list was knowledge of the work process. That list included, among others:

- The workers;
- The supervisors;
- The managers (production, operations, finance etc.); and
- Competent advisors (such as; safety and health professionals, subject specialists (e.g. health physicists, engineers, other scientists etc.).

Risk management identified what are deemed to be potential risks in an operation or activity; followed by a determination of how likely it was that workers might be exposed to the hazard(s) and with what consequences. There was an element of the educated guess involved in that process and certainly in the late 1990s the assessment process rarely included the perspective or experience of the person exposed to the hazard(s).

Risk management had a historical link to insurance and financial loss control, however human loss could not be automatically placed in the same loss control model. Financial risk management looked for the level of loss below which financial stability would be affected and recovery was in jeopardy. Human loss, on the other hand is absolute and not recoverable, accordingly a different approach, operation analysis and control (McAleenan and McAleenan, 2001; 2002) was called for. An approach that started further back in the work process at a point where human loss was not an option and where the entire operation could be explored and safe solutions identified before any possible harm was realised.

OAC analysed the entire operation, in consultation with the workers, an idea advocated by Robens (1972), Ayers and McAleenan (2008) and Ayers (2011), which worked to identify the whole gamut of hazards inherent in the operation. Having worked out all of the interactions between the hazards the next stage was to put forward workable controls that would ensure that the operation was safe to start, safe to execute and safe to complete. All avenues, safety, health and wellbeing were to be included in the analysis. This new paradigm (OAC) recognised the central role a competent worker (McAleenan and McAleenan 2007; 2008) had to play in maintaining safe workplaces. It was not appropriate that workers remain as bit players or worse still play no role at all. Workers' competence in delivering the work activity should never be understated nor underestimated. To reiterate, a major issue with designing work processes is essentially one of competence, and by that the author considered competence in its truest sense. Not just knowledge, skills and experience as was the often-quoted definition. Additionally, competence meant having the resources to complete the task with safety, health and wellbeing appropriately addressed and having the authority to make the decisions within the workers' sphere of control and influence (McAleenan and McAleenan, 2010). What that meant was that all stakeholders (workers, supervisors and managers) had to be fully engaged and participate in the process of designing a safe work process. So many times 3rd parties became involved and took over, effectively neutering the intellectual capability of those most allied to the work itself. In those circumstances mistakes or misunderstandings were a real possibility along with a reluctance to comply from those who knew 'better' ways of successfully executing the work process. In that sense 'design error' almost certainly crept into the process. OAC was about involving and listening to the people who knew the job best when working towards a comprehensive, prevention orientated work process. Notwithstanding those comments there could be a role for 3rd party involvement, providing it was in the sense of an expert advisor, helping the main competent people come up with a good, business friendly, safe and healthy work process. The OAC model developed presented a new paradigm for safety, health and wellbeing (and ultimately environmental management), which presented innovative prevention practices that work across industries and across national boundaries.

## 4.3 Justification for the OAC model

At the time the need for a break away from the risk management approach was becoming compelling (McAleenan and McAleenan, 2002). In March 2001 the author initiated a discussion within the safety profession using the Institution of Occupational Safety and Health (IOSH) online discussion board. The purpose of that critical discourse (Appendix 4) was to engage the key members of the safety profession in a critique of their chosen positions. The subject ‘Risk management – A Failed Paradigm’ was deliberately polemical to engage as many as possible in the debate. The author concluded there was sufficient evidence that while the intent behind the language was the driving force for the necessary societal changes the language of risk management, had led practitioners into indefensible positions of accepting that a degree of harm was inevitable in the workplace and beyond. In a discussion on corporate governance at the World Congress on Occupational safety and Health (McAleenan and McAleenan, 2008) argued the conventions and rules that direct the relationships between all the stakeholders had to ensure that any structures and procedures effectively achieve growth and stability while maintaining the integrity of the organisation and its stakeholders.

However, the definition and intent held within the safety profession at that time when taken at face value appeared to exhibit ignorance of the dialectic that governed the working out of the contradictions inherent in the differing spheres of influence within an organisation and its social milieu. This in turn impacted upon the organisation's efficacy in creating the correct conditions for achieving growth and stability.

Legislation; initially the Health and Safety at Work etc. Act 1974 (OPSI, 1974) and laterally that which emanated from EU Directives (i.e. The Management of Health and Safety at Work Regulations 1999), required the identification and evaluation of risk. There was no specific requirement to risk manage [10] in legislation, although common usage of the risk management term appears to stem from loss control in the insurance industry, spreading without full due diligence into the world of workplace safety and health. ILO (1999) refers to risk assessment and the need for OSH management, perhaps the conflation of the two terms coupled with the linkage back to insurance risk had resulted in the inappropriately named risk management in safety health and wellbeing. McAleenan and McAleenan (2015) set out to explore the numbers behind the risk assessment assertions to determine the validity or otherwise of the approach. The existence of the safety professional exposed some of the contradictions that pervade the issue of effective governance, in particular when, as a function of management, that role conflicts with the notion that the competent company is composed of proficient decision making employees. Here lies the contradiction; a dichotomy had been created whereby safety had become separated from and transformed into an adjunct to a task where once it had been an integral aspect of competent worker performance. As an adjunct it was susceptible to "bottom line" thinking where the "unnecessary" is jettisoned in the face of dwindling profitability, and held onto only to the extent that legal minimums are met. Maharaj (2008) argued that the organisation that took the reactive problem-

[10] The origin of current safety and risk-management concepts can be traced to the need to master the extremely high hazards inherent to the use of nuclear energy. Background information can be found at the web sites of the International Atomic Energy Agency (IAEA), at www.iaea.org, and the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), at www.nea.fr.

solving approach to safety generally had a perception that safety issues were divorced from day-to-day business operations and consequently they were sub-ordinate to the demand on thee time of senior management.

### 4.4 Validation of the model - OAC in Practice

The operation analysis and control (OAC) model had been designed to ensure that work operations would be carried out in strict accordance with all relevant ‘safe working’ procedures. In that way people, plant and property would be protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced. The earliest iteration of the OAC model (Appendix 2) integrated all aspects of the work operation, addressing safety, health and wellbeing matters at each stage. OAC went through a number of iterations, the original being more closely aligned to the conventional Risk Assessment/ ‘Plan, Do, Check, Act’ approach (Health and Safety Executive, 1997) in HS(G)65. However, HSE had also moved forward in their thinking (Health and Safety Executive 2013) when they said:

> “*Truly effective health and safety management requires competency across every facet of an organisation and through every level of the workforce”.*

The basic premise had remained and that is that operations should be safely designed and executed. With that the safe and healthy ‘from conception’ to ‘final execution’ approach had arrived in the world of safety management. Later versions of OAC, including the most recent [11] (Appendix 2) had a more simplified, although not simplistic approach reflective of a much more pragmatic attitude. The stages were clearer and the questions much more focused and direct.

OAC was first introduced to a Northern Ireland government agency with approximately 2,000 employees in 1997 (McAleenan and Orr, 1999). At the time the Agency had six Safety Advisory Officers and a Senior Safety Advisor,

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[11] The current OAC model (McAleenan 2015) is a cosmetic change only from the 2002 version. The 3 stages are presented in detail in Appendix 2

hundreds of risk assessments in various stages of readiness and a safety manual that resembled a paper mountain. A widely held feeling, at that time, was that everything relating to safety, health and wellbeing could be left in the capable hands of the 'safety guys', the inference being that they alone had responsibility for ensuring safe and healthy working conditions for their 2000 colleagues. Perhaps this notion stemmed, in part, from Robens (1972) who, while acknowledging the managers' direct operational responsibility for safety and health also discussed the possibility of specialist safety advisors sitting within the line management chain, in much the same way as personnel officers did. While this notion didn't find its way through to legislation [HSWA, 1974] it nonetheless remained widely held across industry and within the safety professional fraternity. However, the Management of Health and Safety at Work Regulations 1999 (and the previous 1992 version of the Regulations) gave effect to Council Directive 89/391/EEC in UK and made clear, what was implicit in Health and Safety at Work etc. Act 1974 (OPSI, 1974) was that employers are to appoint competent persons to:

> *"...assist him in undertaking the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions..."*

Unfortunately, competence and expertise are often conflated. Whereas occasionally specific expertise may be needed to solve a particular matter the routine operation analysis and control is well left in the capable hands of competent operatives and managers. The relevant point being that there was a requirement for the use of 'competent person[s]' to assist, not safety officer[s]/ advisor[s] as discussed in Robens (1972) and McAleenan and McAleenan (2007; 2008). The changing emphasis for the Northern Ireland government agency, post 1997, was an acknowledgement that all its employees, from members of the Board to operatives out on the ground each had capability, resources and the responsibility to ensure safe and healthy working conditions within their sphere of control and influence. To make this transition as smooth as possible the existing group of safety advisors was gradually reduced in numbers, each one assuming a more appropriate role of providing technical assistance when requested by management and staff until eventually when the transition to OAC was completed the safety advisors were totally phased out. Two requirements had been central to the success of the approach. Firstly, the Board defined their priorities with health and safety integral to their business strategy and secondly they accepted that competence is an essential attribute for all of their employees; noting that competence extended to having adequate resources, responsibility to achieve and the authority to act within their sphere of control.

When introducing the OAC approach, the then Chief Executive (McCoubrey, 1998) indicated that in the first 5-year period the organisation would consider a 10% year on year reduction in lost time accidents as an acceptable and achievable target, forecasting that a £1.1m saving was to be realised in the process. What transpired was a 20% year on year reduction, dropping from 68 to 22 (Table 4.1. In the first 5 years of operating OAC (up to 2003/04) the lost-time accident levels for the Northern Ireland government agency fell by over 68% (McAleenan and McAleenan, 2005). Over the years that followed the Board of Directors set new and more challenging lost-time accident reduction targets (Table 5.1).

Table 4.1: Lost-time Accident Targets

| | 1998/ 99 | 1999/ 00 | 2000/ 01 | 2001/ 02 | 2002 / 03 | 2003/ 04 | 2004/ 05 | 2005/ 06 | 2006/ 07 | 2007/ 08 |
|---|---|---|---|---|---|---|---|---|---|---|
| In Year | 68 | 50 | 34 | 41 | 39 | 22 | 22 | 25 | 23 | - |
| 3 year Average | 56 | 55 | 50 | 42 | 38 | 34 | 28 | 23 | 23 | - |
| Board’s Target | | | | 49 | | 41 | | 36 | | 19 |

The resultant reduction in the reportable accident rate was more than double the performance target set by the Chief Executive Officer at the time of the OAC models introduction. The OAC approach was audited, using traditional audit techniques each year since it’s introduction where compliance rates of 85% to

95% was found to be not uncommon, a testament to the acceptance of the approach across the organisation (McAleenan and McAleenan, 2005).

## 4.5 Examples of OAC in use

Eighteen years since it was first developed and put into practice companies using the OAC model (Appendix 2) or elements of it examine the requirements necessary for successful and therefore safe and healthy outcomes and ensure that the resources; human, material and financial, are in place to control their operations. The OAC approach is expandable from simple everyday tasks to the comprehensive task of governing the organisation.

The Institution of Highways and Transportation published highways environmental management model (McAleenan, 1998), based on the first iteration of OAC and in 2014 ASSE published an environmental management model, based on the most recent OAC iteration (McAleenan and McAleenan, 2014).

In 2002 a multinational food manufacturer invited the author to carry out a review of the degree of their compliance with the CoSHH[12] requirements. The purpose of the review was to make a determination of the extent to which the company had assessed and controlled the use of hazardous substances (including carcinogens and biological agents) in compliance with the statutory requirements. The results of which would guide the development of a Chemicals Safety Analysis and Control procedure, an OAC specialist iteration, which would integrate into the company's Task Risk Analysis (TRA) procedures. Following a preliminary meeting in December 2002 a gap analysis approach was agreed upon and relevant documentation developed and produced. The exercise was not a full compliance audit. In May 2003 an on-site observation and review of procedures took place as well as detailed an examination of samples from relevant documentation and materials. Ultimately it was important that the company be aware of their own duty to develop CoSHH and/ or Material Safety Data Sheets (MSDS) documentation in respect of any new substance created as a by-product of any of

[12] CoSHH – Control of Substances Hazardous to Health Regulations 2002.

their processes. In 2012 (Maharaj, McAleenan and McAleenan, 2012) the OAC was introduced to nuclear new build industry in the operation training manual ahead of the beginnings of the building of Britain's new nuclear programme.

OAC acknowledges that each functional role within an organisation had a sphere of control and a sphere of influence. Its effective integration into the workplace requires that workers, at all levels, are allowed the freedom to deliver on their functional responsibility, with a degree of autonomy synonymous with their defined role in the organisation. Elsewhere in Australia Ayers (2010) has suggested that:

> "*We should be asking ourselves - what can possibly go wrong and what can we, as an industry, do to prevent it from going wrong. Then we can stand back, and decide if we've done enough*…."

# Chapter 5. Project 2: Prevention through Design Education

## 5.1 Aim and Objectives for the PtD Education Project

Aim: To produce the education packages that will develop engineers' capability to deliver vision zero through the application of inherently safe[r] design principles and practices.

Objective 1: Adopt and adapt inherently safer design principles from chemical processing for use in civil engineering design.

Objective 2: Develop a designer training package that embodies the principle that designs should be capable of being built, used, maintained and eventually demolished safely.

Objective 3: Integrate PtD theories and practice into undergraduate degree programme.

Objective 4: Test the reliability, validity of the developed PtD resources.

## 5.2 PtD: Motivation behind the approach

How can designers' competence be developed and used in a meaningful and beneficial way to ensure the development of inherently safe[r] designs and the delivery of the objective that designs should be such that they can be built, used, maintained and eventually demolished safely. Since that responsibility lies initially and primarily with designers the aspiring engineer's journey to independence of thought and action requires the provision of practical information about safe design principles. The UK Work and Pensions Committee (WPC, 2008) suggested the need to rationalise safety and health education and training, placing it within the competencies of those responsible for the health, safety and welfare of workers and consumers and thus on the syllabi of all courses and programmes of professional and vocational study.

In Québec, at the 2nd international seminar on occupational safety and health education and training this was recognised as a necessity by the International Social Security Association (ISSA, 2003). The Québec Protocol (ISSA, 2003) placed an onus on educational bodies and the institutions responsible for the prevention of industrial accidents and occupational diseases to ensure that safety, health and wellbeing was incorporated into the educational processes of all occupations, that mastery of the requisite safety, health and wellbeing knowledge and practice are a focus of evaluation and that the education bodies adopt exemplar practices as well as polices and rules. In the UK the Joint Board of Moderators (JBM) has determined that graduating engineers must demonstrate attitude, knowledge and a degree of competence particularly with reference to health and safety (JBM, 2011). A fully functioning professional design engineer must be in a position to demonstrate that they have sound knowledge of scientific, engineering and technical principles, experience of construction processes and knowledge that extends to future use, maintenance and demolition (McAleenan and McAleenan, 2010).

In the various life cycles of the construction industry designers' play a pivotal role in ensuring the development of inherently safe[r] designs. Behind any construction project there are fundamental principles that are universally applicable and which the designers must keep to the fore, not least of which were the requirements to eliminate or reduce the impact of hazards that might arise during construction work. Since the earliest design decisions can fundamentally affect safety, health and wellbeing early intervention are called for to ensure that all of the necessary safety and health issues have been appropriately addressed. And it is for this reason, outwith the various pronouncements (ISSA, 2003; WPC, 2008, Donaghy, 2009; JBM, 2011) that a didactic response to the embedding of PtD thinking in the professional design engineer was essential.

The act of "prevention" is derived from both the common law and statutory duties of care that, in specific relationships we are obligated to act in a manner that will not cause harm to others, whether by design or through negligence. As far back as 1955 the US National Safety Council (NSC, 1955) suggested that design engineers should consider the need to have safety built into every aspect of production. While this may have been the early thinking that would lead to prevention through design principles it hadn't gone far enough in not addressing the need to consider long-term use, maintenance and eventual demolition. The International Labour Organisation (2004) contended that it had never accepted the notion that injury and disease "*go with the job*", arguing that prevention worked. Article 1 of the Promotional Framework for Occupational Safety and Health Convention (ILO, 2006) states that the:

> *"…term a national preventative safety and health culture refers to a culture in which the right to a safe and healthy working environment is respected at all levels, where government, employers and workers actively participate…through a system of defined rights, responsibilities and duties, and where the principle of prevention is accorded the highest priority."*

This was reiterated in the Seoul Declaration (ILO, 2008) and even though the preventative culture argument was gaining momentum prevention through design as a concept wasn't yet in vogue. 1994 saw the introduction of the first version of the Construction (Design and Management) Regulations (CDM); UK's response to the EU Directive 92/57/EEC temporary or mobile construction sites (EUOSHA, 2015b). Which, while not being explicit was paving the way for what would become the prevention through design approach. The essential safety requirement (OPSI, 1974) required that a manufacturer take responsibility to ensure that their products are safe from harming workers and those who ultimately use their products. In that regard it is implied that those who design the product must consider the impact and implications of their designs on those who come into contact with the finished product as well as those involved in the production process. There is nothing new in the idea that those who design and construct a building should be held accountable for any failings in their design that leads to injury to another. Lawmakers have been developing regulations that were not about supporting this as established practice, but rather were about compelling designers to adopt the practice, (McAleenan and McAleenan, 2009).

Looking internationally, in Australia for example, three jurisdictions (Western Australia, Queensland and South Australia) have statutes that oblige designers to address safety with a fourth, New South Wales, requiring safety through design on public works projects over $1m. (Gambatese et al, 2009) and in the UK the CDM regulations 2007 (updated in GB in 2015) imposed similar duties on designers. The regulatory compulsion to design safety in does not automatically translate to a requirement to include safety, health and wellbeing education and training as a compulsory component of engineering education. Donaghy (2009) recommended:

> *"…there should be a review by the Higher Education Funding Council…the industry and professional bodies on the adequacy and relevance of university or college curricula in covering design, health and safety awareness and risk management issues".*

Additionally, and without regard to legal obligations professional bodies, such as the ICE, have always held that it is a professional and ethical responsibility for members of the learned society to deliver safe and healthful products. Moving forward it was at the HSE consultation (McAleenan and McAleenan, 2005) into the revision of the CDM regulations when HSE started to recognise PtD as a core tenet of construction safety when they indicated:

> "*…designers are in a unique position to eliminate or reduce the risks that arise during construction work and have a key role to play in the design and management of construction projects*".

Ultimately in the revised legislation (Health and Safety Executive, 2007) the need for designers to consider the safety, health and wellbeing of maintenance and demolition workers arrived at the forefront of regulatory requirements.

Designers and constructors are the two essential roles in any construction project that, between them, must possess the necessary competence and skills to successfully and safely realise their client's vision. The project will not be successfully delivered unless the two parties (designer and constructor) in tandem with the Client, properly co-ordinate their activities, communicate their requirements and co-operate in the delivery of the project. The design safety analysis and control process (McAleenan and McAleenan, 2004), derived from the Operation Analysis and Control (OAC) model integrated all aspects of the project process including those associated with the design elements in construction. Underpinning this approach to safety is the elimination of risk through the absolute control of all stages of the process.

The model suited the requirements of European Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites with particular reference to project preparation. Since CDM 1994 there has been a principal contractor with responsibility to co-ordinate all aspects of the construction phase it should stand to reason that the design phase of the project should also have a principal with specific responsibility to co-ordinate all aspects of the design of the project, extending into overseeing its successful construction (McAleenan and McAleenan, 2004). CDM could easily have placed a duty on principal designers and principal contractors to co-ordinate safety and health issues, communicate relevant or significant findings and to co-operate with each other to ensure a safe and healthy outcome. This would meet the spirit of the Temporary and Mobile Workers Directive, remove any unnecessary bureaucracy presented by the addition of a separate co-ordinator and ensure that control and influence of the designer and constructor are not neutered. The author's ideas are now reflected in the 2015 version of the CDM regulations in GB.

## 5.3 PtD: The Educational Challenge

Students develop their competence through active participation in a variety of learning settings, both formal and informal, therefore it is for educators and mentors to assist students comprehend the importance of designing safe products, buildings, processes and systems. The challenge with the introduction of the construction design and management regulatory requirements introduced first in GB in 1994 was the dissemination of the appropriate information to all of the relevant players in construction. Indeed, identifying who all the players were was an immediate challenge before deciding on a range of educational training delivery modes. In addressing the fundamentals behind the range of educational and instructional programmes (design and delivery) the author was mindful of Dearing's (1996) suggestion that lifelong learning points to the need for higher education to be increasingly responsive to the needs of students and to be explicit about what it is providing through learning programmes, and their expected outcomes. Education must never be about what is contained in the book (Swamy, 2005), or in the head of the educator. It has to be experiential and lifelong. Cognisance was also taken of the Quality Assurance Agency (QAA) for Higher Education's Framework for Higher Education Qualifications (2008); developed and maintained by QAA in response to the Dearing recommendations, which required that "*When designing and approving programmes, higher education providers will wish to ensure that a coherent learning experience is delivered*".

Additionally, Vivekananda (cited in Swamy 2005) stated; "*Education means that process which character is formed, strength of mind is increased and intellect is sharpened. As a result of which one can stand on one's own feet*". Mao Tse Tung's treatise (cited in Freire, 1972) resonates as much with education philosophy as it does within the world of work:

> *"All work done for the masses must start from their needs and not from the desire of any individual, however well intentioned...We should not make the change until, through our work, most of the masses have become conscious of the need and are willing and determined to carry it out."*

This suggests that the students have to be ready for and see the need for the changes else they will remain unresponsive to them and all efforts will at the least have been misplaced and at the worst have been lost. Mao's sentiments are recognised in the writings of Marton (1981), quoted in Biggs and Tang (2003) when he reintroduced the term 'phenomenography' to describe that the students' perspective determines what is learnt and not specifically what the teacher intends the learning outcome to be. Phillips (2009) cites and praises the ASSE's championing of the ExCEED (Excellence in Civil Engineering Education) programme in its approach to improving the teaching capabilities in order to considerably enhance the students learning experience. Stacey, Simpson and Schleyer (2009) discussed the means for ensuring that *"...safety-critical professionals received adequate education in health and safety risk management"*, citing Lord Cullen at the Hatfield Rail Enquiry:

> "*Education of engineers should deliver professionals who understand their professional responsibilities for the safety of the public, including the need to act on safety critical defects…*".

Education theories and models developed in the 1960s and 1970s resonated in a number of the cases studied with varying degrees of success in imbedding safety, health and wellbeing awareness and competence in graduating engineers. There is no absolute, no one solution that stands head and shoulders above the rest proclaiming that this is the way forward (McAleenan and McAleenan, 2010).

### 5.4 Cognitive Learning and Constructive Alignment

In the foreword to EUOSHA's document of mainstreaming OSH into university education (Copsey, 2010) the Director states, *"...if OSH is truly to become an integral part of business management in all sizes of organisations then all future managers and professionals need relevant [risk] education, not just those who work in high risk*[13] *sectors*". Copsey (2010) describe 36 good practice example cases across the European Union where OSH education has been embedded in the curriculum. Central to the design of the PtD educational programmes was the author's belief that construction professionals need to be educated to high standards in order that they are equipped to provide their client with flexible, self-motivated designers, with a significantly well developed sense of ethics reasoning. Accordingly, favouring experiential or cognitive learning as opposed to behaviourist approaches, more suited to the 'results orientated' school than a 'student-centred' one (Race 2001), and cognisant of experiential learning approach the author sought to create the PtD educational programmes, incorporating one facet of cognitive learning; problem based learning (PBL) referred to by Freire, cited in Pietrykowski (1996) as problem posing education, which challenges the student to develop or further develop their critical thinking skills, regardless of their learning style (Honey and Mumford, 1992).

PBL is a generic term; described by Woods (1996) as "*...one of the most exciting and powerful educational options that has appeared in the last 30 years*", allows the students to practice and process the learning in a meaningful and productive manner. The premise being that it promotes and encourages learning as a life skill, not a means to an end. Yusof et al (2005) asserted that PBL, "*…encourages self-directed learning and knowledge construction...and ongoing cognitive restructuring*". This approach would help the students' progress, from whatever

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[13] Perhaps more correctly 'high tarrif'.

point of learning and development they presently held, to the highest stage of contextual knowing (Baxter Magolda, cited in Carney, 2002). PBL was also generally recognised as promoting the requirement for a deep approach to learning and fitted with the concept of constructive alignment, a term coined by Biggs and Tang (2003), which in effect simply means ensuring that the learning activities match the intended learning outcomes in a manner that allows the student to construct meaning from any exercises they are required to do. Constructive alignment is about creating a supportive and encouraging learning environment/ set of learning activities where the educator facilities self-managed learning in the students. This approach facilitates deep learning. The Higher Education Authority cautioned that constructive alignment is neither easy nor straightforward, requiring that the educator "*...constantly modifies course design and delivery, constantly trying to work closer to the unattainable perfect constructive alignment*." (HEA, 2004).

## 5.5 Authors input into Designers' CPD

Professional training and development has evolved over the years as an integral aspect of corporate social responsibility. Forward-thinking corporate organisations no longer saw the development of the intellectual and professional capacities of their staff as being beneficial only to the individual. Rather, it had becoming more widely accepted that the professional development of staff significantly influenced organisational output and corporate advancement. The challenge of managing safety, health and wellbeing continues to confront organisations of all sizes, whether it is in operation management (OAC), McAleenan and McAleenan (2001; 2002) or in prevention through design (DSAC), McAleenan and McAleenan (2004). As key performance indicators continued to grow tighter amidst varying socio-economic demands, organisations could have inadvertently come under more pressure to compromise the safety, health and wellbeing of their staff. However, where a dynamic and effective staff training and re-training regime had been established across the strata of an organisation, the potential for sustainable achievement of an optimum safety, health and wellbeing performance was high. Construction was a key industry and a force for economic stability. With the international trends in relation to alternative fuels exploitation, unstable economic climates, oil and gas price volatility and the like; organisations needed to continue to rely on intellectually and professionally enhanced designers to cope favourably with the emerging challenges.

The Institution of Civil Engineers (ICE, 2015) has defined continuing professional development (CPD) as:

> *"The systematic maintenance, improvement and broadening of knowledge and skills, and the development of personal qualities, necessary for the execution of professional and technical duties throughout your working life".*

This view aligned with the professional engineers' rules of professional conduct, which went further than just requiring members to develop themselves but asked that professional engineers assist others in their CPD.

With that in mind and with the onset of the CDM regulations the author had developed a series of seminars, case study working days and full training programmes for practising engineers (Appendix 5) to assist their professional development. Within the NI Government Agency, the author wrote a safety management procedure, SM14 (Appendix 5) to fit with the revised CDM requirements espoused in the revised ACoP of the early 2000s. The procedure and the training was delivered around the DSAC approach to design safety (McAleenan and McAleenan 2004), aligned to OAC (McAleenan and McAleenan, 2001; 2002) and with the PtD principle in mind. It is worth noting that the SM14 document of 2002 (Appendix 5) referred to a lead designer responsibility. The duties and responsibilities applied then in the author's work (Appendix 5) were reflected in the CDM 2015 regulations in Great Britain (Health and Safety Executive 2015c). Accordingly, any professional development training programmes needed to grasp the new concepts, not just behind the CDM requirements but also had to reflect the theme of the EU Directive (EU OSHA 1992).

A fundamental aspect of the training delivered to practising engineers was that evidence was needed that they had achieved a level of knowledge, understanding and that their capability to perform the duties required of them under the CDM regulations confirmed. The training, which included a written competence based assessment, was created to tested candidates' knowledge and understanding. A threshold pass of 75% was agreed with the Client as being satisfactory. Some candidates failed the assessment on the first attempt and re-sat it and the message that was sent out across the remaining prospective candidates was that this programme was being taken seriously by the training provider, their employer and ultimately their professional body. A few hundred candidates undertook the training and assessment between 2002 and 2008 and all the successful candidates were entered onto a register, providing they had the experience to go along with the tested knowledge and understanding. All the details were held by their employer as evidence of their ability to act as Lead designers/ CDM coordinators. Appendix 5 gives further details of the training programmes on offer.

## 5.6 MEng/ BEng: Safety Engineering and Disaster Management

Emergency response projects are complex and highly demanding, involving a number of different and well-coordinated courses of action. It is vital that these complex activities are well planned. Consequently, the success of aid projects in emergency response from planning through to the completion stage depends on the various parties' understanding of partnership and mutual trust and the common objectives that they share. The roles of parties involved in post-disaster reconstruction have to be carefully arranged for the performance of reconstruction activities. The safety engineer's role is that of a specialist, educated in the core engineering and scientific disciplines with the additional critical educational base connected with the principles of prevention through design and dealing with humanitarian crises. After many years of ad-hoc teaching of safety from an ethical perspective and prevention through design at under-graduate level the author joined a team at the Ulster University with the distinct agenda to develop a full structured degree programme, focussed specifically on safety engineering and disaster management (Appendix 6). The rationale for the combining of these two, seemingly disparate disciplines was that recent years had seen many natural disasters (such as: floods, hurricane winds and earthquakes) and technological disasters (such as fires and explosions at chemical plants, nuclear facilities and both on and off-shore oil platforms). The disasters have been on a global scale, requiring the skills and expertise of engineers from around the world, often at short notice and often with a significant human dimension.

As a safety engineer with high levels of analytical, creative (McAleenan, 2015b) and evaluative skills associated with PtD a graduate of the programme would be in a position to devise mitigatory steps to avert disaster using intelligent engineering and professional emergency management practices. Engineers, with specialist skills in designing structures to withstand potential disasters in the natural and in the built environment, who also have the analytical and creative skills needed to produce innovative solutions to disaster scenarios would be highly desirable/ employable. In the event of natural and technological disasters it is the engineers who are called upon. The two key focal points of the programmes, safety engineering and disaster management, where intertwined perfectly to educate and prepare students for roles within industry. The safety engineering strand concentrates on intelligent design of systems and processes to create more efficient organisations and industries with a highly attuned emphasis on environmental sustainability and inherently safe design for all concerned. The complementary disaster management focus explores the macro issues to prepare students to be able to lead and manage disaster response teams in a truly international context. Students will be prepared to able to respond to both natural and technological disasters equipped with the skills and thorough understanding of their ethical role in terms of designing critical solutions to highly sophisticated problems with the primary aim of preserving or improving human life. Engineers with such a specialist 'safety engineering' skill set and a strong humanitarian affinity would be best placed to help communities in need, anywhere in the world to either avoid or recover from the impact of natural or technological disasters. Both programmes, MEng and BEng, were developed in line with UK SPEC (Engineering Council, 2014) The BEng programme would prepare graduates for

Incorporated Engineer (IEng) status while the MEng would be suited to those progressing to recognition as a Chartered Engineer (CEng). What follows is a selection of some of the modules students on the degree programme are to experience.

### 5.6.1 Humanitarian Engineering

Humanitarian engineering is engineering where human benefit is the primary concern. Engineers have the skills and ability to help people and communities most in need and most specifically in the face of adversity, such as in a post-disaster situation or in extreme emergencies. In a conflicted or turbulent environment humanitarian engineers are often the first on the scene and often have to make decisions on a limited or zero budget. And while UN and others in world community rally around and find the funds they rely heavily on the services of the humanitarian engineer. This aspect of the degree programme introduces students to humanitarian skills and practices, giving them an understanding of the characteristics of natural disasters, conflicts and complex emergencies. It challenges the students' inspiration and beliefs helping them to work out personal motivation for humanitarian relief work as they conceive the difficulties associated with designing solutions to intrinsically complex and scalable problems.

### 5.6.2 Safety: An International and Ethical Perspective

The industry, set against a backdrop of fatal incidents and fatal ill-health outcomes has much work to do (Health and Safety Executive, 2015a). Central to that is the engineers' responsibility to have the safety, health and wellbeing of workers at forefront of their minds throughout the design process. Inherently safe[r] designs are more than just an aspiration; they are a categorical imperative (Balmforth, 2015). Indeed, they are a professional imperative, enshrined in the engineers' code of ethics.

It is the safety engineer's role to be able to identify and take responsibility for their safety, health and well-being obligations, to be in a position to implement appropriate management systems and to have an understanding of legislative requirements, ethical codes and international protocols as they relate to safety, health and wellbeing. To that end the safety engineer needs to have an understanding of and have the ability to implement a PtD approach to their work, taking account of, among other things, approaches to design safety analysis, OAC, workplace risk assessment, safety oriented method statements in the development of engineering design packages. The programme is designed to address the ethical responsibility and ethics reasoning ability that engineers and their allied professionals need to possess to ensure that the public and workers' safety, health and wellbeing is at the forefront of all that they do.

### 5.6.3 Prevention through Design

Prevention through Design (PtD) also known as inherently safe[r] design has been well established in the process industry. In civil engineering/construction, producing designs that are capable of being built, used, maintained and eventually demolished in a safe and healthy manner has only ever been implicit in legislation since the Regulations were enacted to bring the EU Temporary and Mobile Workers Directive into force. The emergence of the principal designer in CDM regulations (Health and Safety Executive 2015c) lends voice and muscle to the emergence of formalised PtD education at the university level. PtD, the philosophy of safe design thinking that addresses safety, health and wellbeing issues in engineering design projects is a whole life approach that would encourage engineering students to critically reflect upon the safety, health and wellbeing impacts of their designs on individuals and on communities at all stages in the life of an engineering structure. The PtD life cycle is a fundamental aspect of a designer's thoughts and a key intellectual quality of the safety engineer.

PtD looks beyond the idea that reducing/ mitigating the impact of hazards is an operational/ management issue to the realisation that hazards need to be identified at the concept stage, addressed more fully at the scheme design stage and wherever possible/practical eliminated at the detailed design stage. This challenging proposition is the role of the design engineer in a trans-disciplinary team and a core function of the safety engineer as an integral part of the team.

# Chapter 6. Conclusion and Further Research

## 6.1 Impact of Original Contribution to Knowledge

We live in a complex world, of our own making, but is it the world that is complex or is it the rules; laws, codes and guidelines? Perhaps the rules are fine and it is the interpretation of them that creates the complexity. In developing the projects, presented herein the author focussed on finding the simple, not the simplistic in approaches to safety, health and wellbeing. What is wrong with simple? For that matter what is wrong with complex? The challenge is to find the right balance between approaches; complex enough to deliver results and simple enough to be understood by all. Robens (1972) said there is "*too much law*" and that was the backdrop to the introduction of the Health and Safety at Work etc. Act 1974, an all-encompassing law that would for the first time apply to every workplace and every possible work situation.

Following years of reacting to EU directives the conservative government in 2010 set out to reverse the trend of producing new and more regulations in response. Professor Lofstedt was engaged to determine whether UK did in fact still "too much law". Lofstedt (2011) concluded that the volume of laws, regulations and guidelines were not the issue and neither was it their complexity. Rather it was down to misinterpretation (McAleenan and McAleenan, 2014); simple and straightforward made complex through misinterpretation and misunderstanding and it was this that OAC (McAleenan and McAleenan, 2001; 2002) was designed to challenge. The author contributed these views, through membership of the ICE Expert H&S Panel, tasked with contributing to the CIC/ ICE response (CIC/ ICE, 2011) to the Lofstedt review (Lofstedt, 2011).

At the CIB W099 conference (McAleenan and McAleenan, 2009) discussion centred around the idea that workers should go to work and come home again in the same physical and healthy condition.

The author's view (McAleenan and McAleenan, 2014), upon reflection, was that why shouldn't workers come home from work with their health and wellbeing improved, rather than just remaining the same. If, in the culturally mature company, work contributes to the wellbeing of society (McAleenan and McAleenan, 2009), then surely that must equally apply to the individual workers. That is the strongest impact of OAC (McAleenan, 2001; 2002) and prevention through design (McAleenan and McAleenan, 2004).

Reflecting the author's views (McAleenan and McAleenan, 2001; 2002; 204) the Seoul Declaration (KOSHA, 2008) directed that approaches to workplace safety needed to be positive, benefit focussed with wellbeing and welfare to the fore. This approach, this new mindset, coming from the International Labour Organisation was an external validation of the author's research and project development sine the 1990s. The twin elements of critical conscientiousness and dialogics; are central to a worker driven approach to operational control, the objective being to understand the world, expose its contradictions and act, illuminated by understanding (McAleenan and McAleenan, 2013).

Fundamentally the worker and the company have to listen, co-exist, interact and respond, however there needs to be an awareness of and being prepared to work with the contradictions that might arise. The author's twin survival objectives (McAleenan and McAleenan, 2010), safety of the worker (survival of the individual) and profitability (survival of the company) laterally had a third objective added, the enhancement of society (McAleenan and McAleenan, 2014). The impact OAC has for workers' safety, health and wellbeing relies on the fuller competence definition; that is going beyond skills, knowledge and experience (McAleenan and McAleenan, 2007; 2008) to include authority to make appropriate decisions and resources to deliver safe and healthy operations.

The introduction praxis, embracing the principle of prevention had the effect of taking workplace safety to another level allowing room for the principle of enhancement to potentially become the norm (McAleenan and McAleenan, 2014). This was ethics reasoning at its highest level (McAleenan and McAleenan, 2011; 2012), respecting the dignity of all and recognising the equality of worth of all living things.

Despite the complex nature of the world of work and the rules by which we all live we can come to look at the world through each others eyes (McAleenan and McAleenan, 2014) and understand each others position. Outwith individually held goals and through the application of OAC and PtD (McAleenan, 2001; 2002; 2004) there is a common goal that workplaces contribute to the wellbeing and welfare of our workforce and society.

## 6.2 The route to Vision Zero Harm

The author believes in a world of work where vision zero harm is a real prospect. There cannot be employers or workers who deliberately set out to harm, maim or even kill their workers or their colleagues. The incidents still happen, despite the best efforts of many. So if it isn’t a deliberate act to injure and collectively we possess the technological and intellectual capacity to eliminate harm from the workplace and we have an ethical and moral responsibility to try and achieve that, what isn’t working?

The big picture question then is can vision zero harm be achieved in the construction sector today, by 2020, 2030 or in some other future date?

The choice is not one an individual can make but if on one particular day in the future every person on every construction site would do everything possible to ensure no one was harmed that day could it be repeated the next day? And the next... What is needed is collaboration between two powerful forces. Industry and academia between them have the total capability to research, investigate and instigate research findings that have relevance and impact. If only the two sides of the one coin would spend the time getting to know each other’s wants and wishes, then that can happen. Perhaps first in a small way, but if the impact of such beginnings can show positive results then the lessons learnt can be copper-fastened and moved further out into other parts of the construction industry and then beyond. There is a real sense of urgency as ILO (2015) are continuing to report deaths from work-related injury and ill-health in excess of 2 million annually. But if every worker, employer, every researcher in this field asked what can I do today to ensure the vision zero harm becomes a reality? Could the objective be achieved? The author believes it could. The questions, going forward, that will help this progress are:

- How well do education, training, and professional development prepare design professionals in the provision of inherently safe[r] designs?
- How can research into safety and health deliver improvements in workers' conditions and their quality of life?
- What progress towards achieving 'vision zero' is likely to be brought about from current research across all jurisdictions? and
- Are the ethical and moral challenges understood around the globe and addressed appropriately in research projects?

Despite best intentions much work is still needed to determine how these and other related safety, health and wellbeing questions are being addressed in industry and across academia. Just as ILO (2015) has the intention to create worldwide awareness of the critical issues affecting workers' safety health and wellbeing so too should the active researchers in the field. OAC worked when a NI Government agency used it to its full capacity, reducing their accident rate by almost 70% of its pre-OAC figures. Putting OAC together with the PtD principles within an organisation to meet vision zero harm objective gives the organisation the capacity to fully deliver. Going forward with the combined power of OAC/ PtD worked in harmony is the answer. However as suggested earlier there would likely be merit in starting this process using the diagnostic functionality of OCMI to establish the organisation's readiness to embrace OAC/PtD. One further area to focus upon is 3rd level education, mindful of the challenges[14] set out by the EU (EASHW 2010) and the call set out in the Québec City Protocol (ISSA 2003). The report and the protocol are concerned with the technical and the 3rd level education; preparing students for a world of work where safety, health and wellbeing is such an integral aspect of their professional thinking that vision zero can become a reality. Future research in this field has to be focused on how we can collectively realise such an ambition and it is here that organisations such as CIB W099[15], presently developing its next Research Roadmap (publication date post-May 2016 after the World Building Congress), are invaluable. As a collective of safety researchers across the globe there is scope to take a considered and collective view in advancing research in PtD education and operation. The research findings in this area can be the catalyst for persuading accrediting bodies of the Engineering Council UK, such as the Joint Board of Moderators and the Engineering Accreditation Board that prevention through design needs to be a central tenet of all future civil engineering degree programmes, moving far beyond their requirement for "*H&S risk management*" (JBM, 2011).

### 6.3 The lessons learned along the way

The OAC approach has been consistently based on the premise that work activities must be viewed and carried out holistically with no unnecessary separation and devolvement of functions to others, particularly in the realm of

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[14] Examples of the challenges include: the need for partnerships with individual universities, faculties and professors; convincing professors of the importance of OSH education; high existing demands and pressures on undergraduate time; lack of suitable OSH educational materials for the university level; lack of university-level teaching staff with OSH expertise and/or active and participatory education skill

[15] CIB ("Conseil International du Batiment" roughly translated as International Council for Building) is a worldwide network of over 5000 experts from about 500 member organisations with a research, university, industry or government background, who collectively are active in all aspects of research and innovation for building and construction.

One of CIB's Working Commissions CIB W099; Safety and Health in Construction is committed to the advancement of safety and health of construction workers using all necessary tools to accomplish this end include designing, pre-planning, training, management commitment and the development of a safety culture. CIB W099 believes that advancing the health safety and wellbeing of workers and the society within which we operate is a fundamental aspect of our professional and ethical being.

critical decision making vis-a-vis safety. Since the 1990s environmental responsibilities have in some considerable areas been devolved to the health and safety departments, as too has quality in some companies. It is not uncommon to see the acronym HSEQ to describe the role of the safety practitioner. In parallel with the increasing social and political awareness on environmental matters has been the developing concept of sustainability, once associated with environmental sustainability it now often explores the issue of business sustainability. Behm (2009) asked whether any industry that kills and injures its workers can be realistically called a sustainable industry, thus integrating the quality of workplace conditions with an ethical stand on whether the business should much less could be sustained.

As the OAC approach was being introduced to businesses (McAleenan and McAleenan, 2001; 2002) it was being refined via regular presentations to gatherings of professional bodies; safety, construction, engineering and academic. Each refinement was a logical development of the preceding concepts, starting with the holistic approach to workplace safety, through the application of the principles of effectiveness to work management, through to the rational re-integration of responsibility and authority to make decisions related to the work being undertaken. In the process it became apparent that realistic considerations of work activities must be seen in the context of their relationship with other activities on the shop floor or construction site as well as in the context of their wider societal and environmental considerations, locally, nationally and globally. The twin objectives for the sustainability of any business is for its activities to be good for the individual worker and good for the company and in this we have echoes of Fromm's (1947) contention that what is good for the individual must of necessity be good for humanity.

At the 2008 World Congress in Seoul it was reiterated that safety and good health at work was a fundamental human right enshrined in the UDHR, (McAleenan and McAleenan, 2008). Delegates were also warned of the negative impacts that globalisation and the then impending recession would have on the safety, health and wellbeing of workers and on the communities from which they came. As the leading employer, worker and government bodies come together to seek ways and means of eliminating the annual workplace death toll of 2.3 million in other arenas and educational institutions discussions and activities are exploring ways in which Fromm's (1947) case for a science of humanity to be a core component of all educational and professional development. In this a well educated worker in considering what is good for him in the context of his work activity will also be considering how that good meets the needs of his fellow man. The next step in the development of workplace culture centres not solely on whether a worker goes home as safely and as healthfully as he arrived that morning, but on how the culture of the workplace contributes to the overall benefit of society. In a recent personal correspondence (anon 2015) with the author a practising safety person lamented the consistent failure of anyone "*to take a serious approach to sorting out our industry in terms of H&S and skills*". The correspondent concluded:

> "[This] *industry will never change here unless something drastic happens. I have wasted enough of my energy and personal pain trying to change it. The industry and the people that should know better simply don't get it.*"

What prompts someone to reach such a conclusion? Is it that this person's grasp of the processes of history, and the ability to translate thought into action is shaped solely by negative constructs? When Freire (1970) spoke of "conscientization" and Sherratt (2012) spoke of "social constructionism" there is just as much the possibility that negative constructs shape the negative attitudes that pervade the consciousness of individuals. If there exists a myriad of negative quality experiences and the numbers experiencing them are large then the challenge in the implementing of OAC/ PtD thinking and action is huge, yet not insurmountable. Seeing the vastness of a problem can sometimes see only obstacles and with that comes feelings of inadequacy.

If you can break any safety, health or wellbeing challenge down and see each smaller manageable portion as a problem with a solution; praxis, then positive constructs can become the standard. As each person commits to the competent to become competent concept, aligning that thought to a continual challenge to investigate and improve upon the challenges faced in the workplace there is the opportunity to bring safety, health and wellbeing to its pinnacle. It is the authors firm belief that the adoption of the tools and techniques critiqued and reflected upon herein will allow workers to regain control of their safety, their learning and their destiny and what logically follows is the achievement of the definitive workplace and design objective; vision zero harm.

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# Appendix 1: Published work - chronological sequences

## A1.1 International Conference Presentations and Papers

McAleenan, C. and McAleenan, P. 1998. Managing Safe Entry into Confined Spaces. Institution of Chemical Engineers (IChemE) Internet Safety Conference Paper.

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McAleenan, P and McAleenan, C. 2008. Corporate Governance – The Role of the Safety Professional. Proceedings World Congress on Safety and Health. June 2008. Seoul, Korea

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McAleenan, C and McAleenan, P. 2010. An Exploration of Structured and Flexible Approaches to Developing OSH Competence in Engineering" Proceedings All Ireland Symposium on Built Environment Education. January 2010. Belfast, Northern Ireland.

Gunning JG and McAleenan C, 2010. Safe-T-Cert: An Irish solution to the universal problem of assuring construction safety. Proceedings Association of Researchers in Construction Management (ARCOM) Conference. September 2010. Leeds, UK

McAleenan, P and McAleenan, C. 2010. Calculating your flight distance – the evolution of safety in the competent company. Proceedings Canadian Society of Safety Engineering Professional Development Conference. September 2010 Halifax, NS, Canada.

McAleenan, C and McAleenan, P. 2011. Safety – Turning the Event into a Process: 15 Years On. Proceedings World Congress on Safety and Health. September 2011. Istanbul, Turkey.

McAleenan, C and McAleenan, P. 2011. Methodology for the Evaluation of Qualitative Factors in Safety Culture. Poster Presentation: World Congress on Safety and Health. September 2011. Istanbul, Turkey.

McAleenan, P and McAleenan, C. 2011. Enhancing Ethical Reasoning in Design Education. Proceedings CIB W099 Conference. August 2011. Washington, DC, USA.

McAleenan, C and McAleenan, P. 2012. The degree of sophistication of ethics reasoning amongst first year under-graduate students. Proceedings CIB W099, Modelling and Building Health and Safety September 2012, Singapore.

McAleenan, P and McAleenan, C. 2013. Maturing workplace culture in the context of evolved ethical agency. Proceedings CIB World Building Congress. May 2013. Brisbane, Australia.

McAleenan, C., Behm, M., Weatherup, R. and McAleenan, P. 2013. Public and Workplace Safety and Health in Hydraulic Fracturing. Proceedings CIB World Building Congress. May 2013. Brisbane, Australia.

McAleenan, C and McAleenan, P 2014. The application of deductive logic to determine the objective conditions impacting upon cultural maturity. Proceedings CIB W099, Achieving Sustainable Construction Health and Safety. May 2014. Lund, Sweden.

McAleenan, P and McAleenan, C. 2014. Leadership - a negation of agency or an opportunity to develop autonomous action for workplace safety. Proceedings CIB W099, Achieving Sustainable Construction Health and Safety. May 2014. Lund, Sweden.

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## A1.2 Conference Papers for Presentation in 2016

McAleenan, C. and McAleenan, P. 2016. The Construction Project Managers' OSH Responsibilities. Proceedings CIB World Building Congress 2016, Tampere, Finland. May 2016.

McAleenan, P. and McAleenan, C. 2016 An Ethics Reasoning Approach to Health and Safety in Construction. Proceedings CIB World Building Congress 2016, Tampere, Finland. May 2016.

## A1.3 Journal Papers in Preparation in 2016

McAleenan, P. and McAleenan, C., 2016. Calculation of the number of synergistic hazards and risks on construction sites that limits the efficacy of risk assessment matrices. (Submission to ICE's Management, Procurement and Law journal).

## A1.4 Books/ Chapters Authored

**1997**

McAleenan, P and McAleenan, C., 1997. Confined Spaces Expert. Downpatrick: Expert Ease International

**2010**

McAleenan C and Oloke D (eds) "ICE Manual of Health and Safety in Construction". London: Thomas Telford Ltd.

**2012**

Maharaj, R., McAleenan, C. and McAleenan, P., 2012. Managing Safety in Construction: EDF Energy Nuclear New Build. Manchester: ARMSA Consulting

**2013**

McAleenan, C and McAleenan, P (2013) "Health and Safety for Construction Professionals" EEI Publishing, Downpatrick, NI

**2014**

McAleenan, C. and McAleenan, P., 2014. Management of Environmental Impacts. In Hill, D (Ed) (2014) "Construction Safety Management and Engineering" American Society of Safety Engineers. Des Plaines, Il

McAleenan, P. and McAleenan, C., 2014. Ladders. In Hill, D (Ed) (2014) "Construction Safety Management and Engineering" American Society of Safety Engineers. Des Plaines, Il

**2015**

McAleenan, C and McAleenan, P., 2015. Leadership – A Negation of Agency. In Opoku, A. and Ahmed, V. (eds) In Leadership and Sustainability in the Built Environment. Routledge, London,

McAleenan C and Oloke D (eds) 2015. ICE Manual of Health and Safety in Construction (2nd ed). London: ICE Publishing

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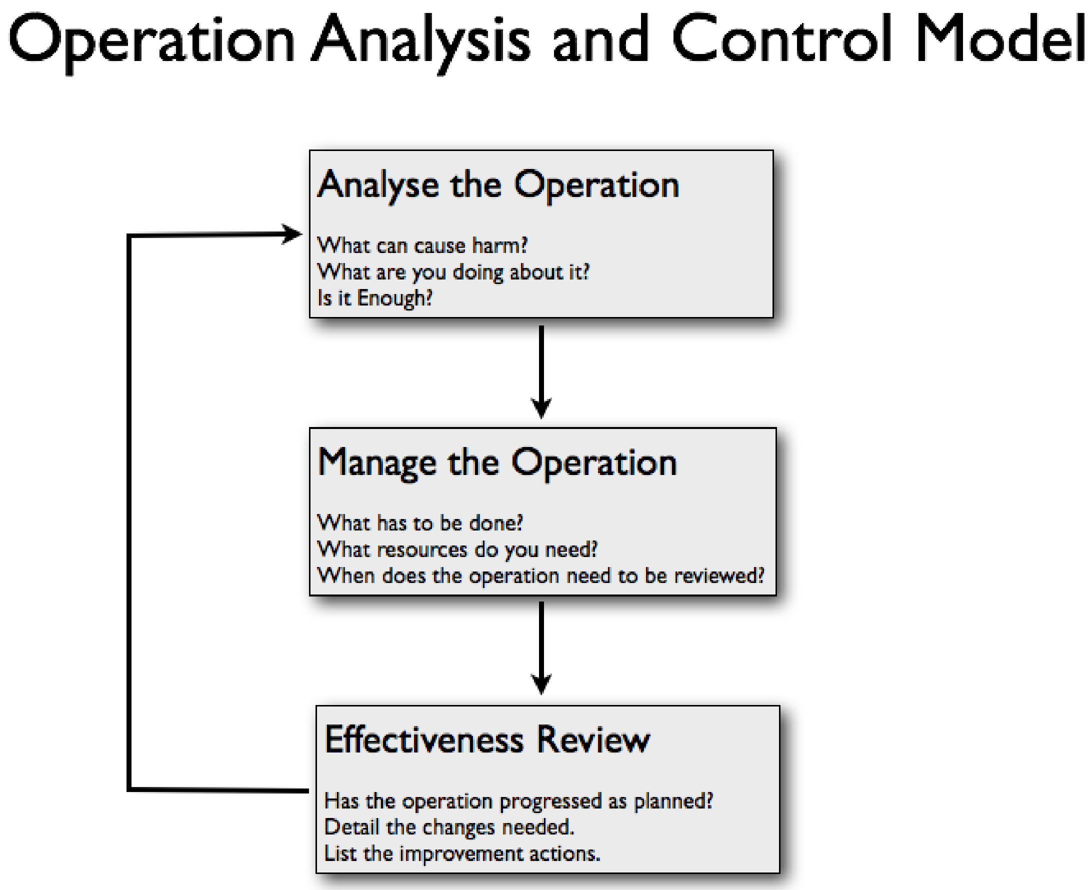
## A1.5 Project Outputs

- A new model for Safety Management: Operation Analysis and Control
- Prevention through Design Training Manuals
- Safety Engineering and Disaster Management Degree Programme.
- 4 Databases: Operational Analysis and Control, Chemical Safety Analysis and Control, Compliance Tracker and Accident Recorder.
- 30+ Papers (listed above)
- 3 edited books
- Chapters in 5 books
- CD ROM: Confined Spaces Expert
- Confined Spaces Licensing and Certification Programme.
- Protocols for Low Voltage Working, Temporary Traffic Management, Contractors' Relationships Protocol, and Manual Handling of Kerbs.
- Safety Manual (including 4 full working safety websites;
    - Roads Service [intranet];
    - web-safety.com;
    - confinedspaces.com; and
    - notoneaccident.com.
- Pocket Safety Book
- Environmental Handbook
- Audit and Accident Reports (Internal and External validation)
- 3 National/ International Awards.

## Appendix 2 The OAC Model Explained

A2.1 The OAC model.




A2.1.1 Stage 1: Analyse the Operation.

1. What can cause harm? (Look for the harm factors in the work operation itself, the workers, the materials, the machinery and plant, the public & visitors and the environment).

2. What are you doing about it? (Once you know what can cause harm you look for the controls that are needed to prevent that harm from occurring).

3. Is it enough? (At this stage, before embarking on the work operation, consider whether you have done enough to prevent harm. If necessary seek specialist advice e.g. from trade or professional associations, manufacturers, your National Statutory Safety Body, other safety professionals etc). Things can go wrong and it important to try and anticipate that as early as possible. Ask;

   - What could go wrong?
   - How could it happen? and
   - How would you deal with it?

   Asking the questions at the outset focuses the mind and ensures that you have considered all the foreseeable incidents and planned for them. Additionally you are prompted to consider what emergency plans you need to have in place prior to starting an operation.

A2.1.2 Stage 2: Manage the Operation.

1. What has to be done? (Having carried out the analysis you must list what has to be done to ensure a safe outcome to the work operation. E.g. have you made your employees aware of what can cause them harm and what they must do? do you know what training they need?, are there written safety instructions? Does everyone know who is responsible and for what? etc).
2. What resources do you need? (Material, human, financial). It is important that, having identified the resources, you make them available. (Some will be needed well in advance of any work operation. Build your controls into your budget and business plan).
3. When does the operation need to be reviewed? Believing that you have a safe workplace is a sure way of ensuring that you have not. Like every aspect of your work safety needs to be continually managed and improved, as necessary. It is important therefore that a time or circumstance is set for reviewing the effectiveness of the management controls. The review period could be;
    - When new processes or new equipment is introduced to the operation,
    - When new techniques have been developed,
    - When statutory obligations require it,
    - When resources inputs are set to change,
    - When an accident or incident occurs, or
    - At regular intervals (determined by the nature and complexity of the hazards present).

    Note: The list above is not exhaustive. Carry out an effective review at any other time, should you feel it is warranted.

A2.1.3 Stage 3: Effectiveness review.

1. Has the operation progressed as planned? Things change or things can go wrong. You need to be aware of the effects of any change and try to anticipate how they will need to be dealt with. Ask yourself the following questions;
    - What has changed since the last operation analysis?', 'What effect will it have on operational management?', and 'How will it be dealt with?',

      If nothing has changed then note that the review has taken place and set the next review date.

    Where things have gone wrong ask the following;

    - 'What went wrong?', 'How did it happen?', and 'How did you deal with it?'.

    Note: We do not always get it right but if an accident does occur that is no reason to give up or to accept lower standards. Accepting accidents as inevitable is fatalistic[16]. The objective of integrating the highest standards of health and safety

[16] In fact defining incidents that lead to harm (or which could have resulted in harm) as accidents portrays a belief that some things are unforseeable and therefore 'just happem'. Supplant unforseen and you have a situation where OAC has not been completed beofre the work activity

with improved business performance means that the end product/ service must be achieved in a manner that protects employees and the public from harm. Operating to any less a standard will only guarantee a negative outcome and ensure that accidents continue.

2. Detail the changes needed. If changes have occurred then itemise them and consider how they will affect the operation.
3. List the improvement actions. Draw up an action plan, identifying the resources implications, managers responsible for completing the actions and the timescales for completion.

A2.2 Work objectives

Set your work objectives to include…

“...tasks/ activities are to be completed on time and in a manner that does not cause harm to the workers, the public, other non-employees, and/ or the organisation.”

In practice this means that for construction activities structures are to be designed in a way that they can be built, used, maintained and eventually demolished, taking full account of the safety of the construction workers, end users the maintenance workers, those tasked with eventual demolition/ partial demolition and anyone else that may be affected by the construction activities.

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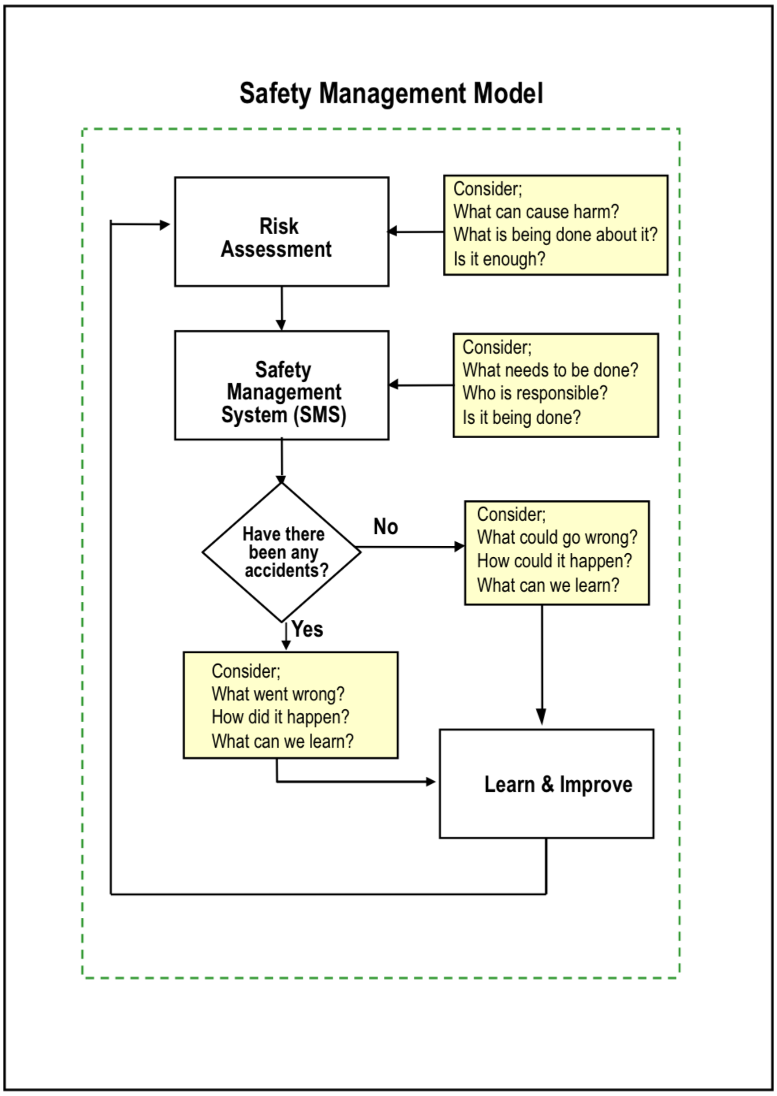
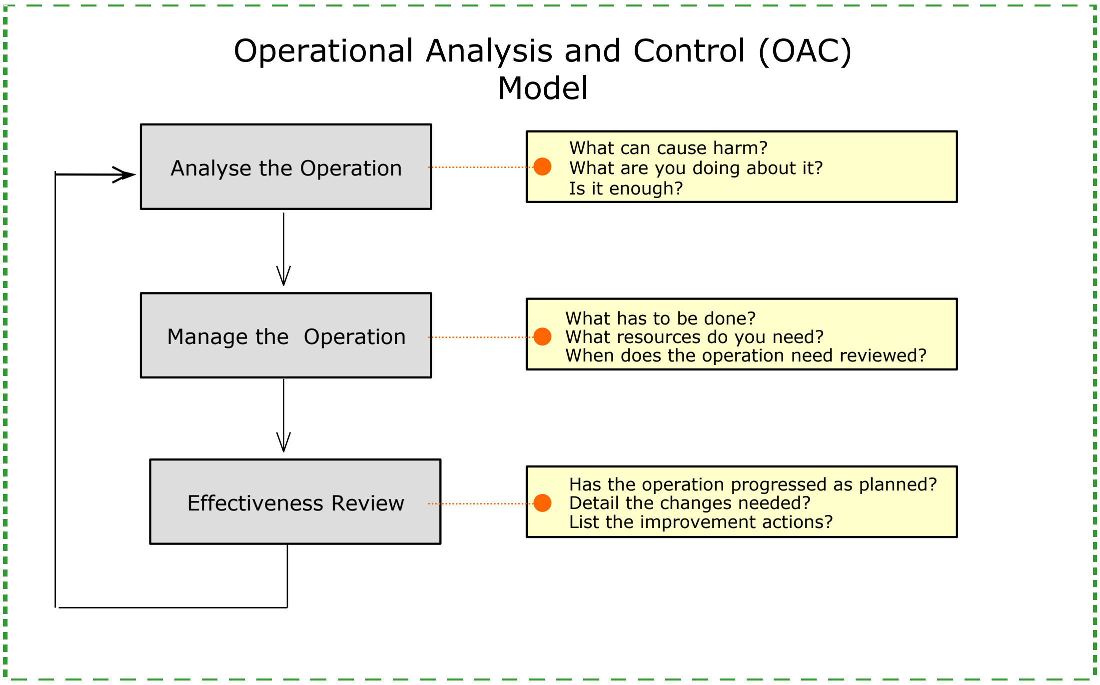
started. In the proving of OAC [Project 2] a discussion takes place on how this aspect expanded to meet the needs.

# Appendix 3 Various Iterations of the OAC Model

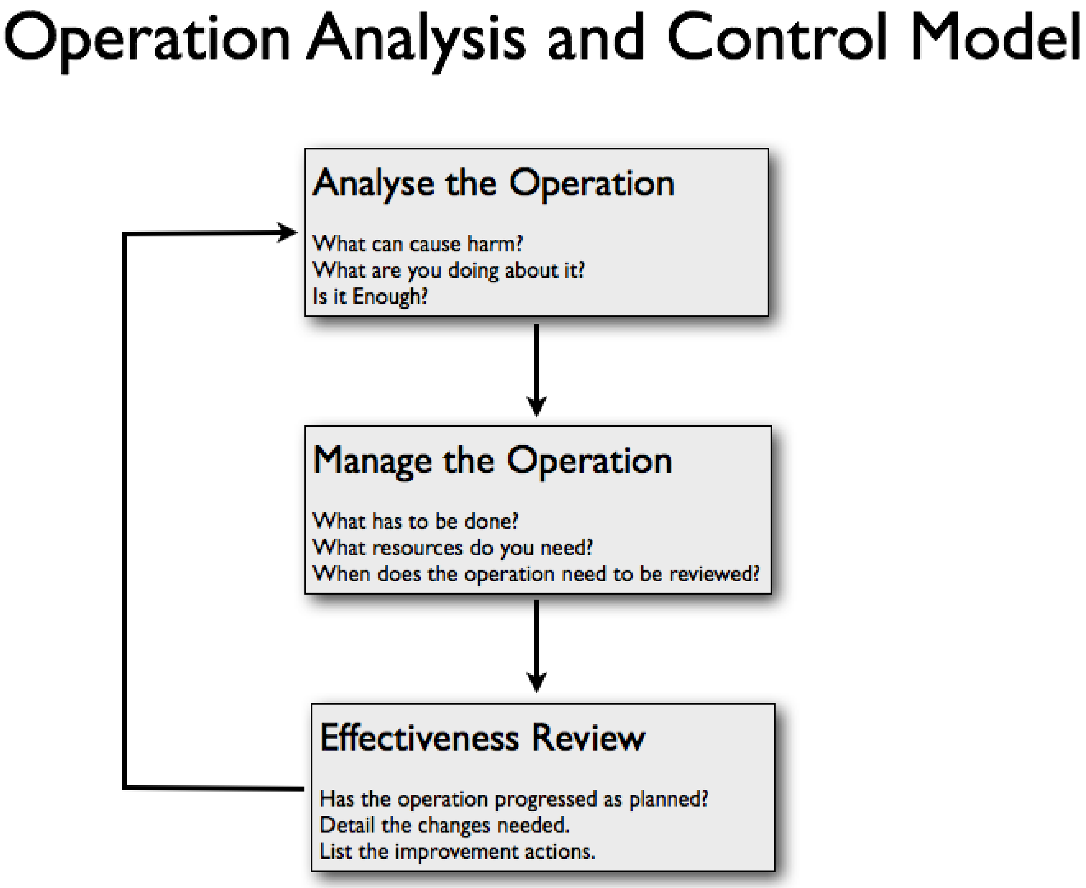
A3.1 The OAC model 1998.



A3.2 The OAC model 2002.




A3.3 The OAC model 2015.



# Appendix 4 Risk Management – A Failed Paradigm

## A4.1 Critical Discourse

The subject 'Risk management – A Failed paradigm' was deliberately polemic to engage as many as possible in the debate. The discussion opened [paraphrased and edited for anonymity] as follows:

> *"I [the author] would contend that risk management has failed and that it is time to rethink the strategy! There is no reason to believe that anyone accepts that zero fatalities are an impossibility, but the question; "If it is truly a 'high risk environment' how could you ever have zero fatalities?" goes to the heart of the current critical evaluation of the concept of risk and risk management. The premise being that there is both the technological and intellectual capacity to achieve zero fatalities, but what prevents this is the ideological basis underpinning risk management. Logically 'risk management' is a 'self-contradicting' statement that promotes the concept of acceptable levels of risk, i.e. injury and fatality. 'Risk' is a subjective measure of the possibility of danger being realised, used where there is an absence of certainty. In this absence of certainty you have 'chance' and it is chance that determines which of two outcomes are likely in the workplace; incident or no incident. Management is the authoritative control of operations. Where there is control of an operation 'chance' is removed and the only possible outcome is that which has been established at the outset. If the outcome cannot be determined with certainty then chance exists and any action taken is a gamble that the actual outcome will in fact be the desired one.*
>
> *In practice risk management posits an acceptable level of risk and proceeds to manipulate the circumstances to increase the odds in favour of a non-injurious outcome. Ultimately, by accepting and acting on any level of risk we are gambling with the safety of workers. It is suggested in the original posting and elaborated upon that what we mean is that we put in place sufficient control measures to reduce the risk in hazardous environments. On the contrary safety management should not be interested in reducing the risk, rather it should be making the case for managing any operation in hazardous environments such that there is no risk. If safety, not the risk, is managed and we can control the safety of the operation then it does not matter how hazardous the environment is since the operation (properly analysed and controlled) is no longer dangerous and the outcome will always be non-injurious. People do and probably will continue to die in, for example confined spaces, for the foreseeable future but it is not because fatalities and major injuries cannot be prevented, rather it is because risk management acknowledges this as an acceptable outcome".*

## A4.2 The Discourse with analysis.

Contributors to the discussion could not agree with one [Subject A] stating:

> *"…I cannot accept your argument that "rather it is because risk management acknowledges this as an acceptable outcome". No death in confined spaces is*

*either a risk management decision or an acceptable risk management option. Death occurs through a number of factors, and the results nearly always point to a lack of risk management, not an acceptance that this will be the outcome of an acceptable risk management strategy. This would obviously contradict all H&S law and standards. Death is avoidable, perhaps with the exception of rare, unforeseeable and uncontrollable circumstances. The true risks lay in the facts that incompetent or untrained and inexperienced persons are often in control of, or undertaking such work. Management often fails to either recognise this or provide suitable and sufficient levels of experienced and competence to ensure that works carried out are done in a healthy and safe manner".*

Further thoughts in support of risk management [Subject B] viewed risk management a little 'less cynically', trying to take a holistic approach to the subject and view the overall aspects of risk management as per BS8800, OHSAS18001 & HS(G)65- a cycle of continuous improvement, much as any other subject, skill is improved continuously.

[Subject B] *"No-one, it was argued by proponents of risk management or at least very few, have the resources to go from X amount of risk to zero risk in an instant. Risk management they argue is about identification of hazards and prioritization, which means that it takes time to eliminate all the possible hazards that face an organisation. And organisations change, ergo, new hazards arise that present risks that need to be addressed, or "managed" according to current legislation, so the cycle of continuous improvement goes on. There is also the application of the reasonably practicable risk/ sacrifice equation. Skill and experience is required to get it right. Risk management failed? I don't think so. In fact, it has probably only just begun"*

Interestingly the argument relying on the reasonably practicable risk/ sacrifice equation aspect works directly in opposition to the language in use and supports the failed paradigm argument. Thinking back to linguistic analysis and more specifically where descriptive linguistic analysis seeks to determine and interpret how society receives and reacts to the language as it is used this point has critical position, in as much as its effect on the society in question; the workforce is that sacrifice means occasional injury or fatality. A point so poignantly expressed by the entry of Subject C to the debate who posited;

[Subject C] "*As the working environment is continuously evolving ... there are always going to be injuries and deaths in the workplace. I[t] should be the primary role of Risk Management to aim for complete control of risk. While realising that to achieve this is virtually impossible*".

The following interjection from Subject D pointed towards support for the new paradigm, wrapped up in support of the old. Descriptive linguistics analysis points towards the language of intent. The need to go beyond the words to see the effects the language is having on the behaviour of the individual or the group. In this respect as the following argument rolls out look for the intent behind the words.

[Subject D] (corrected for spelling and grammar only) *"I have always held the opinion that zero accidents are a realistic goal but that in achieving that,* *managing risk has to prioritise the risks in order to eliminate them. Risk management is about determining what risks require managing to what level. Determining the level of acceptable risk is just as important as managing the risk itself. Looking at larger organisations, some accept a level of fatality! The rail industry accepts 1 trackside fatality per 100000 employees as the target. If this is achieved then everyone will be happy and give themselves a pat on the back. But now we are moving into zero accidents as a statement for promoting cultural change. As a safety manager, I always define the goal a zero accidents. I will never accept an accident as acceptable and as such risk management must conform to that thinking in my organisation. In reality, when investigating accidents and incidents I do understand where foreseeable and unforeseen boundaries lie and try to make them foreseeable and solvable in the future. My simple answer is that you will get closer to the standard of safety you really want if you define it. If you accept that accidents will happen in accordance to the national averages and you are happy you are just under them, good for you. Risk management is about constant improvement; what we accept today we must not accept tomorrow. Risk management is the tool for the job and I think its real value lies in identifying the very things its being challenged on, what is acceptable and how long can it continue."*

So perhaps throwing out the challenge that risk management is a failed paradigm had driven its devotees to clarify the reasons why they were in support of risk management. Was it just a language difference and if so was that reason enough for change, for a new approach, for a more precise and targeted model going into the future? Language influences our thinking overtly or subliminally, something marketers know only to well. In recent times road traffic accidents have come to be referred to as road traffic collisions. Why? What was the difference between 'accident' and 'collision'? Straight away it was clear that the collision was the outcome of an undesired traffic event, whereas accident had the potential to go towards blame or its avoidance under the argument that accidents are 'unforeseeable' events. Going back to the earlier part of the millennium the National Institute for Occupational Safety and Health (NIOSH), a US Government Agency defined accidents as 'control failures' (McAleenan and McAleenan 2005) in an attempt to put the focus squarely where it belonged; a failure in control. Interestingly Subject E defended this position well, while still suggesting opposition to the author's core premise. For instance one of Subject E's arguments;

[Subject E] *"I cannot agree with [author's] statement that "If safety, not the risk, is managed and we can control the safety of the operation then it does not matter how hazardous the environment is since the operation itself is non-hazardous and the outcome will always be non-injurious" I believe that this point of view is not only erroneous but also dangerous, because if you assess the risks from the hazards implicit in the operation without taking into account those risk factors introduced by the physical, psycho-social or organisational environment you will fail to examine all the risks and are unlikely to manage or carry out the work safely, even if no loss occurs. For example, in working in confined spaces in limestone regions carbon dioxide may migrate into confined spaces under low pressure, if this is not taken into account in the safe working procedures and practices, then asphyxiation could result, even though the atmosphere is not deficient in oxygen. In this case the fact the risk was not accessed does not mean that it was acceptable, nor does it mean that because someone was not asphyxiated does it necessarily mean that he was safe!"*

Subject E conflated hazard and risk as many often do (McAleenan and McAleenan 2002). And in consequence the argument presented, once the word ‘risk’ was replaced with ‘hazard’ in Subject E’s argument works directly in support of the thinking behind the author’s original premise. In further support Subject E agreed that risk management promoted the concept of acceptable levels of risk, that risk management posited an acceptable level of risk and that risk was subjective, however Subject E did not accept that risk was totally subjective, or that we were gambling with the safety of workers. This was an understandable response to a deliberately polemic interjection to an ordinarily caring and impassioned profession. Subject A interjected at that point in support of Subjects E’s statement:

> [Subject A] *“In summing up the debate the following the following became clear. There is no risk in an operation. Either you will achieve your objective or you won’t. Risk exists only in ignorance, that is that you don’t know whether you will succeed or fail. A managed operation, however, is one in which all of the hazards have been considered and the controls have been put in place so that the operation itself is free from risk. If risk continues to exist it can only be because there are insufficient controls and that may be for a variety of reasons*”.

Challenging an accepted paradigm was not cynical as Subject B suggested since the concept of continuous improvement had to extend to looking at how well our management systems had performed and to moving on when they fail to meet our expectations. Risk management was not a divine paradigm above evaluation and criticism. On the contrary by exposing its limitations we could go beyond it to a paradigm that would achieve the “vision zero harm” objective. Risk management by definition was self-contradictory and as it was practised accepted that an injurious outcome to some work activities was unavoidable such that it merely sought to reduce the likelihood. In UK’s H&S legislation the term: “*so far as is reasonably practicable*”, and in HSG65, BS8800, and OHSAS18000 there was an acceptance of that position. Proper management of the entire operation required that you define your operational outcome (to include a non-injurious outcome), provide the resources and review (as necessary) so as to consider the possibility of failure, prior to commencement, during the process and at various other stages. Also known as: safe to start, safe to execute and safe to finish.

A4.3 Conclusions drawn from the discourse.

Much of what was offered by the safety professionals was defensible but where the risk management paradigm differed was in its acceptance of risk and therefore its acceptance of some failure. Subject C and others stated “*there are always going to be injuries and deaths in the workplace*". Accepting this as an inevitable outcome sets expectations and limitations. Risk management supported this fatalistic approach to safety and sought to limit the likelihood of injury rather than to eliminate it totally. Subject B’s’ statement "*reasonably practicable risk/ sacrifice equation*" and Subject D’s rail industry figure of 1 death in 100000 employees being ‘acceptable’ summed up the point that risk management accepted failure. The dead worker’s family and friends were not going to get much solace from the points raised. However, the point made by Subject D that you “*…get closer to the standard of safety that you want if you define it…”* and that *“…continuous improvement is a necessary part of the management process…”* is valid. In that regard the standards to be set should be a safe start, safe execution and safe conclusion to any work activity.

Subject A’s views that management systems do provide the answer and that actual control measures are the most important safety factor had merit and they linked to Subject D’s point that "*you get closer to the standard of safety that you want if you define it*". You will achieve it if you manage it. There could only be one standard, no matter how you dress it up. Namely that we would produce products or deliver services in a manner that would not injure our workforce or others. That straightforward position, extended included; no damage to the environment or to profitability. In other words, it was not unreasonable to consider all the potential losses and put the proper controls in place prior to commencement. Bearing in mind that a risk is basically the element of chance in an activity, whether it was to be 50:50 or 1: 1,000,000. Every week millions of people in UK put money on worse odds in the National Lottery and most weeks one or more come persons succeed. Work environments where the element of chance is retained (for whatever reason) are environments where every week someone's number would come up. That is why ‘risk management’ costs the UK more the £20bn and the USA more than $127bn each year (McAleenan and McAleenan 2002, Health and Safety Executive 2015a, and Health and Safety Executive 2015b). No matter what the odds were, no matter how well "managed" the activity was, the next time could be that one in a million time because there is no ‘chance rule’ that says that the activity had to be done a million times before the accident occurred. In fact, every time could theoretically be that one in a million time. "Risk Management" simply tries to improve the odds. Roberts (2008) discussed how risk management concepts are generally well understood as a means of identifying safety requirements in product development processes. Roberts (2008) went on to address how the concepts of risk management and an approach to further enhancing safety by identifying key aspects of product functionality and user expectations into development could lead to a robust methodology for deriving product essential performance, and the inclusion of state-of-the-art aspects for optimal product safety development. Further evidence of the intent behind the language driving the necessary societal changes.

# Appendix 5: CDM Training Courses for Designers

A5.1 CDM Course Outline

**Objective:** By the end of this course attendees will demonstrate, through case study and competence assessment, their understanding and knowledge of the processes involved in preparing safe designs, together with the roles and responsibilities under the CDM Regulations and Office of Government Commerce Guidelines.

**Target Group:** All lead/ senior designers and those who will be carrying out coordinator functions defined in CDM Regulations 2007.

| **CDM Course for Lead designers and Coordinators**<br><br>**Safety in Design, Construction and Maintenance (3 days, including assessment)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **9:00** | **9:30** | **11:00** | | **13:40** | **15:15** | |
| **Day 1** | Register | Setting the Scene<br><br>CDM requirements | Design safety analysis & control.<br><br>What do they mean by "Safe to build, use, maintain and demolish"? | **Lunch @ 13:00** | Competence of Duty Holders;<br><br>• Client<br>• Designers and Contractors<br>• Coordinators | Safe construction;<br><br>What Contractors expect.<br><br>What H&S Executive expect. | **17:00 Close** |

<table>
<tr><th colspan="7">CDM Course for Lead designers and Coordinators[17]<br><br>Safety in Design, Construction and Maintenance (3 days, including assessment)</th></tr>
<tr><td rowspan="2">Day 2</td><td colspan="2">9:00</td><td rowspan="4">Lunch @ 13:00</td><td colspan="3">13:40</td></tr>
<tr><td colspan="2">From brief to design – a Designer's View<br><br>Competency - Advising the client<br><br>Design safety analysis in Practice<br><br>Preparing and presenting pre-construction information.</td><td colspan="3">Case Study<br><br>Part 1a - Identifying Hazards<br><br>Part 1b - Design safety analysis/ Risk Assessment process<br><br>Part 2 - Preparing pre-construction information</td></tr>
<tr><td rowspan="2">Day 3</td><td>9:00</td><td>11:00</td><td>13:40</td><td>15:15</td><td>15:30</td></tr>
<tr><td colspan="2">Assessing Construction-phase plans - Good and bad examples.<br><br>H&S when managing the project - review points.<br><br>Preparing the H&S file.<br><br>Project Hand over – End of project performance review</td><td>Assessments;<br><br>Pre-qualification & tender<br><br>H&S monitoring contracts</td><td>Exam Briefing</td><td>Open Book Exam<br><br>(90 mins)</td></tr>
</table>

[17] Key Reference Material: CDM ACoP (HSE), H&S in Construction (HSE), Achieving Excellence in Construction – Procurement Guide 10 (OGC), and CIRIA Report C604 (**Author's note**: CIRIA report C604 has been superceded by CIRIA report C755, which reflects the CDM 2015 Regulations)

A5.3 SM14 Sample CDM Procedure

**Purpose**

To define the construction, design and management procedures necessary to ensure the proper health and safety management of Roads Service construction projects.

**Scope**

The management and planning of all design, maintenance, construction and demolition work carried out by Roads Service or on behalf of Roads Service.

**Definitions**

- **Construction Work** – refer to Construction Design and Management Regulations 2007 (Reg. 2).
- **Notifiable Project** – where construction work exceeds 30 working days or involves more than 500 'person' days (**Note**: Term Contracts are not notifiable, however specific construction projects carried out under the Term Contract may be).
- **Client –** Divisional Roads Manager/ Project Owner or DBFO Company.
- **CDM Register** – A register of individuals who have the qualifications and experiences identified at Procedure 4.0 (below) and are deemed competent to act as the lead designer or co-ordinator.

**Procedures**

**1.0 Appointments**

a. Roads Service Consultancy (RSC) is to act as Roads Service's lead designer, except where projects are managed by SRI Teams (see Procedures 12.0 and 13.0) or where the Client retains the design brief.

b. Principal Engineers are to select individuals, from the CDM Register, with appropriate competence (see Procedure 4.0) to fulfil the duties of lead designer.

c. Lead Designers are to select members of their design project team who are competent for the task, sufficiently resourced and aware of the extent of their authority.

d. The Client is to appoint a co-ordinator at the start of any notifiable projects.

e. The Client is to appoint a principal contractor for any notifiable projects.

**2.0 Notification of Projects**

a. The co-ordinator is to notify HSE (NI) of any projects that are expected to last more than 30 days or involve more than 500 'person' days using Form NI 10.

**3.0 Co-ordination and Co-operation**

a. Lead designers are to ensure co-ordination and co-operation between members of the project design team in order that health and safety is properly addressed within the design and procurement process.

b. The co-ordinator (normally the lead designer) is to ensure that the health and safety aspects of the design process have been addressed and to check that different design elements work together without causing danger.

**4.0 Competence – Designers and Co-ordinators**

a. The Head of Roads Service - Transportation and Engineering Policy Unit (TEPU) is to maintain a CDM Register listing people competent (including staff from the Partner organisation) to act as lead designer and co-ordinator.

b. The CDM Register is to be available on the Roads Service Intranet.

c. The CDM Register will identify individuals who have the qualifications and experience identified in Procedure 4.0 (d & e) and who have achieved greater than 75% in a written assessment set by Roads Service.

d. Lead designers and co-ordinators must have;

- A sound working knowledge of health and safety in construction work,
- A thorough knowledge of the design process, and
- Experience of the site processes likely to be involved in the project and in future maintenance, refurbishment or demolition.

e. Lead designers and co-ordinators with the following minimum qualifications and experience will be eligible to be considered for the CDM register;

| Category | Description | Minimum Qualification & Experience |
|---|---|---|
| **A.** | Projects requiring Technical Approval or Geotechnical Certification | CEng MICE (or equivalent) with relevant experience. |
| **B.** | For all other projects | Engineering Degree + 3 years relevant post-qualification experience (inc. design), or<br>Engineering HNC + 10 years relevant post-qualification experience (inc. design) |

f. Individuals who are on the Institution of Civil Engineers' Construction Health, Safety and Welfare Register or who are Fellows of the Association for Project Safety can be listed on Roads Service's CDM Register.

**5.0 Competence - Consultants**

a. The pre-qualification questionnaire is to be used to establish external consultants' H&S competence, before they are admitted to a Restricted List or before a contract is awarded.

b. A member of Roads Service's CDM Register who meets the requirements for Project Category A (Ref 4.0e) is to be included on each consultant assessment panel.

**6.0 Competence - Contractors**

a. A member of Roads Service's CDM Register who meets the requirements for Project Category A (Ref 4.0e) is to be included on each contractors assessment panel.

b. The pre-qualification questionnaire is to be used to establish a contractor's technical/ professional ability in relation to health and safety competence and resources before they are admitted to a Restricted List or before a one-off contract is awarded.

**7.0 Resources and Timing**

a. The Client is to ensure that all the necessary information and resources are made available and that adequate time is allocated to projects.

**8.0 Training**

a. Before being allowed unaccompanied onto a construction site new recruits and staff new to construction are to be trained to recognise hazards on construction sites and to understand the requirements of construction related H&S procedures and protocols.

b. Individuals; attending sites, are to be familiar with relevant site hazards and associated control measures.

c. Training and/ or instruction (including any necessary refresher training) for staff with construction responsibilities is to be linked to design needs and to the operational safety controls sheets, appropriate to their particular work activities.

**9.0 Design Safety Analysis**

a. Designers are to ensure that their designs can be built, used, maintained and eventually demolished, taking full account of the safety of the construction worker and anyone else that may be affected.

b. Designers' H&S decisions are to be determined through designers' safety analysis.

c. For Category A projects (4.0 e) the design safety analysis Form A is to be used.

d. For Category B projects (4.0 e) and for construction work associated with Category 4 defects (Road Maintenance Standards) the design safety analysis Form B is to be used.

e. Lead designer / co-ordinator is to liaise with contractor where onsite design changes are proposed.

**10.0 Pre-construction information and Construction Phase Plan**

a. Pre-construction information is to be issued with the instructions for tendering, identifying any H&S issues that a contractor could not reasonably be expected to anticipate (see Appendix 2 of the Approved Code of Practice (ACoP).

b. The co-ordinator is to advise the Client on the suitability of the construction-phase plan before the construction work is to start.

**Specific to Term Contracts**

c. The construction-phase plan may be accepted in framework format, providing it identifies how it will be developed during the period of the contract.

d. The lead designer/ co-ordinator is to consider whether Term Contractors require additional pre-construction information for specific projects.

**11.0 Contractor performance**

a. The Project Manager / Engineer for the Works is to be informed, by his site staff, if a contractor fails to comply with H&S obligations. The necessary remedial action is to be agreed between all the appropriate parties and recorded on the Contractors' H&S Report.

b. The Contractors' H&S Report is to be discussed at each site meeting and copies are to be sent to the Head of TEPU at the end of each quarter (July, October, January and April).

c. The 6 monthly reviews and the end of contract review are to include an examination of;

- H&S aspects of the Contractor Performance Assessments.
- Actions taken following any RIDDOR incidents and accidents.

d. The 6 monthly reviews, end of contract reviews and Contractor Performance Assessments are to be taken into account when assessing the competence of contractors.

## 12.0 H&S File (notifiable projects only)

a. The co-ordinator is to prepare or update the H&S file and give it to the Client at the end of the project.

b. The H&S file is only to contain health and safety information that will be relevant in future construction projects (see Paragraph 263 & 264 of the ACoP).

c. Clients are to retain and keep H&S files up to date for as long as the roads or structures are in existence.

d. Clients are to ensure that H&S files are available for designers or contractors during any future construction projects.

e. Suitable backup arrangements are required when H&S files are presented in an electronic format.

## 13.0 Design and Build Contracts

a. The Client is to appoint a lead designer/ co-ordinator as soon as is practicable and no later than at the specification design stage.

b. Roads Service - Project Owner is the Client for Design and Build Contracts.

## 14.0 Design Build Finance and Operate (DBFO) Contracts

a. The Client is to appoint a lead designer/ co-ordinator as soon as is practicable and no later than at specification design stage.

b. Roads Service - Project Owner is the CDM Client for DBFO Contracts until a formal transfer of CDM Client responsibilities to the DBFO Company takes place.

c. HSENI are to be informed of the transfer of CDM Client responsibilities.

d. Roads Service's lead designer/ co-ordinators are to liaise with the DBFO Company prior to carrying out additional works on DBFO roads.

## 15.0 RSD as an Internal Contractor

a. Director of Network Services is to approve Roads Service Direct's Construction Phase Plan.

b. Roads Service Direct's Construction Phase Plan is to be reviewed, and revised as necessary at intervals no greater than 5 years.

**Responsibility**

1. Client (DRM/ Project Owner) is to ensure compliance with this Procedure.
2. Head of RSC, Project Managers/ Engineers to the Works and Lead designers/ co-ordinators are to ensure compliance with Procedures 1.0 to 12.0
3. Director of Strategic Programmes is to ensure compliance with Procedures 13.0 and 14.0
4. Director of Network Services is to ensure compliance with Procedure 15.0 (a).
5. Head of RSD is to ensure compliance with Procedure 15.0 (b).
6. Head of T&EPU is to ensure compliance with Procedure 4.0 (a-c and f).
7. Line managers are to ensure compliance with Procedure 8.0.

**Documentation**

- Construction Phase Plan(s)
- Designers' Safety Analysis Form A
- Designers' Safety Analysis Form B
- Form NI 10 (rev)

TOC

- Health and safety file(s)
- Pre-construction Information
- Pre-qualification Questionnaires

**References**

- “Managing Health and Safety in Construction” – Approved Code of Practice (L144)
- “Road Maintenance Standards for Safety” RSPPG E019

A5.4 Briefing Notes for CDM Course

This course covers one aspect of the criteria needed to be a lead designer/ or to carry out coordinator functions. For all of the criteria refer to the Safety Manual - Safety management procedure (SM14) and the CDM Approved Code of Practice.

- Our core business is construction and therefore we have to play our part in improving the safety record of the NI construction industry.
- Fatal Accident Incidence Rates/ 100,000 workers

| | | | | | | |
|---|---|---|---|---|---|---|
| 1999 | - | 13.09 | (NI) | and | 11.26 | (GB) |
| 2000 | - | 5.4 | (NI) | and | 9.02 | (GB) |
| 2001 | - | 7.01 | (NI) | and | 7.77 | (GB) |

10 year average = 9.4 (NI) and 5.2 (GB)

Ken Logan will update us on these figures. Welcome Ken

- In Roads Service we have had our own experiences;
    - Fatality at Stop/ Go board operation (Roads Service worker approximately 2 years ago)
    - Fatality on M1 (Contractor's employee last year)
- Fatalities have a way of bringing the safety message firmly home. We have no reason to accept fatalities in our industry. We have good procedures, processes and guidance.

**What more do we need?**

- Commitment...Easy to say but what does it mean in practice?
- As a major Client Roads service has a robust system for designing and managing construction projects safely (SM14).
- (Note: SM14 recently published is not new to Roads Service, rather it brought together into one clear document the process that had become custom and practice in Roads Service since CDM was introduced in 1995).
- As a Director I can assure you of Roads Service Board members' commitment to making safety work for all of our staff and all those affected by our work.

  (CEO's new policy statement commits Roads service to working to international best practice)

  (CEO appointed RSC as Planning Supervisor - A role that each person attending this course will help us fulfil)

  Roads Service's business strategy and our objectives are prefaced with a commitment to achieve our goals in a manner that does not cause harm to workers or the road user.

- As an individual I can act as I would expect others to act - safely - so that I do not cause harm to myself or to my colleagues.
- My commitment Corporately, as a manager and individually can and must be replicated by each of you and every other Roads Service employee in our own work activities and in our dealing with the wider construction industry. That is our opportunity to positively influence the industry's safety record.
- In this course today and tomorrow you will learn or be refreshed in the skills needed to design safely and manage the construction planning process. That means the ability to design out hazards and to address those hazards that you cannot remove at the design stage. You are already competent in your field, or you wouldn't be sitting here.
- Consider;
    - The buildability of the project,
    - The time and the resources needed to achieve success,
    - How will the contractor safely realise your designs,
    - The needs of the maintenance workers, and
    - The needs of the road user.
- Finally, it is important that Roads Service as an organisation and you as competent Designers and Planning Supervisors;
    - Know the Roads service CDM strategy,
    - Implement it in the areas within your competence, and
    - Can provide evidence of this on demand.

Note: The audit trail includes;

- Completed designer risk assessment checklists,
- NI10 - Notification of Project forms,
- H&S plans and files.

**Some Extra Notes (to use or ignore)**

HSE’s specialist inspectors have conducted a number of in-depth designer audits in the North West over the last 3 years. The findings emerging from these audits fall into a familiar pattern, namely:

- design staff had a lack of knowledge about the risks they were supposed to be addressing;
- design staff had a lack of knowledge about their CDM duties (to eliminate, reduce and inform), combined with a lack of understanding about how to discharge them;
- designers often produced volumes of generic risk assessments that were no help to the contractor and which gave the whole process a bad name. Typically, they were too long, contained little or no essential hazard information, and either stated what the contractor should do to satisfy the law or required the contractor to supply a method statement.
- there was better understanding by the Principals of the design practice, but poor cascade to those operating at a more working level.

If you want to assess yourself using the categories adopted by HSE’s specialist inspectors, please feel free to use our compliance summary sheet.

In addition to these audits, in March 2003, HSE inspectors in the North of England and in Scotland invited designers to meet them on site at 123 major projects. The focus of the discussions was on falls from height, and the collated results showed that:

- About a third of the designers demonstrated little or no understanding of their responsibilities, and only 8% claimed to have received training in CDM;
- Many of the design risk assessments were of poor quality and added little if anything to the safety of the construction process;
- Designers were often abdicating their responsibility to reduce risk in relation to work at height by leaving it to the principal contractor, without first considering how they could change the design in a way which would make it safer to build, clean or maintain, and
- Contractors were struggling to control risk which could easily have been eliminated or considerably reduced by good design.

A5.5 Designers Case Study (PBL) One-day Course

By the end of this session designers will be able to use the design risk assessment (DRA) process to ensure that they can meet their CDM obligations and use the information gathered in this process to prepare pre-tender H&S plans to the standards laid down in the Approved Code of Practice.

To cover;

- Introduction to SM14 and the Designer's role
- Introduction to the Design Risk Assessment process.
- Identifying hazards and preparing design risk assessment.
- Preparation of pre-tender H&S plans.
- CDM issues associated with Term Contracts.

| Time | Session Title | Trainer |
|---|---|---|
| 09:30 | Introduction to SM14 and CDM Obligations | Ciaran |
| 10:15 | Introducing the case study | Ciaran |
| 10:30 | Case Study – Part 1a – Identifying hazards | All |
| 11:00 | Case Study – Part 1b – The Design Risk Assessment | All |
| 12:15 | Feedback | All |
| 12:45 | **Lunch** | |
| 13:30 | Introduction to H&S Plans | Ciaran |
| 13:45 | Case Study – Part 2 – Preparing a Pre-tender Plan | All |
| 15:15 | Feedback | All |
| 15:45 | Term Contracts | Ciaran |
| 16:30 | **Close** | |

# Appendix 6 BEng/ MEng Safety Engineering and Disaster Management

Increasing concerns over climate change and energy security, and the resultant emerging technologies and the growing threat of natural and man-made disasters means that today's engineers are facing a new set of challenges. There is also a need for safety engineers who can design a system or structure, recognise the potential external and internal hazards and the modes of failure, and use this knowledge professionally.

There is nothing that can be done to completely prevent disasters from occurring. However, it is possible to devise migratory steps against disaster with intelligent engineering and professional emergency management practices. Planning can lead to the protection of life, property and the environment. Thus, engineers with specialist skills in designing structures and systems to withstand potential disasters in the natural and the built environment, and those who have the knowledge to plan for emergency and provide solutions in the event of a disaster, are a highly sought after group of experts. Indeed, even from a non-emergency perspective, safety is a critical element for all design engineers. There are no existing undergraduate programmes at Ulster or in any other institutions on the island of Ireland, which equip engineers with this specialist skillset. Therefore, the BEng in Safety Engineering and Disaster Management is timely in addressing this need. The following are the key learning outcomes from the programme…

**Knowledge and Understanding**

- Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of Safety engineering and Disaster Management, and the underpinning science and mathematics.
- Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.
- Appreciate the social, environmental, ethical, economic and commercial considerations affecting the exercise of their engineering judgement.
- Have an ability to integrate knowledge and understanding of wider engineering disciplines to support the study of safety engineering and disaster management.
- Critically evaluate and demonstrate awareness of current problems and the state of the art in safety engineering and disaster management.
- Understand appropriate codes of practice and industry standards.
- Verify principles of design and the design techniques relevant to safety engineering and disaster management.

**Intellectual Qualities**

- Apply appropriate quantitative science and engineering tools to the analysis and solution of problems.
- Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs to address safety engineering problems.
- Comprehend the broad picture and thus work with an appropriate level of detail.
- Critically identify, classify, select and use appropriate computer based methods for modelling and analysing safety engineering problems.
- Classify, and describe the performance of a system and components through the use of analytical methods and modelling techniques.

- Identify appropriate systems and their use for emergency planning and disaster management.
- Initiate, plan, conduct and report on a programme of original research.
- Understand and apply a systems based approach to engineering problems.

**Professional/ Practical Skills**

- Possess practical engineering skills to define a problem and defend a solution, including environmental and sustainability limitations, health and safety and risk assessment issues.
- Identify constraints, manage the design process, and evaluate outcomes relevant to Safety Engineering and Disaster Management.
- Ability to apply quantitative methods and computer based models relevant to Safety Engineering and Disaster Management in order to solve engineering problems.
- Source, understand, and critically review technical literature, current research material, and other information sources.
- Ability to work with technical uncertainty.
- Undertake experimental laboratory work using relevant test and measurement equipment.
- Demonstrate an understanding of the commercial and economic context of engineering processes.

**Transferable Skills**

- Critically evaluate data from specialist areas of knowledge in a variety of professionally appropriate ways.
- Assess complex problems using sound judgement and methods based on the evaluation of scientific evidence.
- Demonstrate high level skills in creativity and innovation in problem solving.
- Exhibit knowledge of management and leadership techniques.
- Accept accountability for a high level of professional and ethical conduct in engineering.
- Manage time and resources effectively for personal, academic and career development.
- Develop skills that allow for personal enhancement, professional development, and lifelong learning.
- Work with limited, incomplete or contradictory information.
- Communicate effectively with specialist and non-specialist audiences.

The BEng Safety Engineering and Disaster Management degree with Diploma in Professional Practice (International) is a sandwich course of 4 years duration.

**In first year** students will develop an understanding of the subject area with an introduction to safety engineering and emergencies; real life case studies of disasters will be used to demonstrate how and where their skills will be needed on graduation. The purpose of this module is to enable students to contextualise their learning in other modules. First year is also the time in which the core engineering topics and underpinning science is introduced.

**In the second year** students will study increasingly specialist topics. The strands of safety engineering, disaster management and emergency planning run across the semesters ensuring there is a balance with the more science based content. The subjects covered will include an international and ethical perspective on safety, which incorporates the legislative requirements, ethical codes and international protocols as they relate to health, safety and well-being. Students will study human factors and behaviours in emergencies and understand hazard and risk analysis as it applies to safety engineering and disaster management.

**Third year** will be spent on placement in industry. This is an integral part of the course.

**In final year** students will deepen their knowledge and learn how to apply the subjects they have studied to solve real engineering problems. There is an emphasis on design and practical problem solving to consolidate the theory studied in previous years. For example, students will study “prevention through design” where they will learn to “design out” or minimise hazards. Structural design, graphical representations for safety engineering, and disasters and rescue engineering will all be addressed. Students will study leadership and management of an emergency response team and complete a dissertation. Details of each of the modules are given below…

## YEAR 1

### Introduction to Safety Engineering and Emergencies

This module will introduce the concepts, theories and principles of safety engineering, emergency planning and disaster management. In addition, case studies of emergencies will be studied to understand the impacts, lessons learned and the role of engineering in managing the associated risks.

### Physics for Engineers

The general purpose of the module is to give students the knowledge framework in physics and develop their skills to apply acquired knowledge to determine solutions to a variety of engineering problems within the subject area.

### Properties of Substances and Materials

Safety engineering and disaster management are evolving fields, requiring increasing levels of competency in underpinning sciences. An understanding of substances and material properties is crucial when resolving a range of engineering problems. The general purpose of the module is to provide students with the fundamental knowledge and understanding of a variety of materials, their classification, properties and applications.

### Engineering Mathematics

This module aims to take students with a range of qualifications and ability in mathematics and bring them all to a level in algebra, calculus and statistics, sufficient for the solution of a range of problems in engineering, finance and other applications.

### CAD & Design

The aim of this module is to familiarise students with the role of the Safety Engineer in the building design and construction industry. The students will acquire basic CAD design skills enabling them to communicate through the use of drawings, and the use of computer design tools.

### Fluid Mechanics A

This module addresses the fundamental principles of fluid statics and dynamics; and sets out methods of analysis for elementary hydraulics. The module aims to prepare students for the design and problem solving associated with simple hydraulic systems.

### Structural Mechanics

This module addresses the fundamental principles of structural mechanics and sets out methods of analysis for simple structures.

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### Chemistry for Engineers

The module is designed to ensure that all students entering the course attain the necessary scope and depth of knowledge of chemical sciences, so that they become competent in physical sciences that underpin safety engineering.

## YEAR 2

### Safety: An International and Ethical Perspective

The professional engineer has to have an understanding of and have the ability to implement a ‘prevention through design’ approach to their work, taking account of, among others, approaches to design safety analysis, workplace risk assessment, safety oriented method statements in the development of engineering design packages.

This module addresses the ethical responsibility engineers and allied professionals have to ensure that public and workers health and safety is at the forefront of all that they do.

### Engineering Mathematics 2

This level 2 mathematics module aims to take those students to a level in advanced algebra, calculus and statistics, sufficient for the solution of a range of modeling problems in civil, building services and energy engineering at undergraduate level.

### Hazards and Risk Analysis

This module is designed to provide a sound understanding of the hazards involved in a variety of aspects of engineering design and introduce various analysis and modeling tools based on fundamental principles of probability and statistics for risk assessment.

### Heat and Mass Transfer

This module builds on the fundamental theory of fluid mechanics, heat transfer and thermodynamics previously covered by students. The focus is on the advancement of these topics with a focus on applications relevant to safety engineers.

### Structural Engineering Design 2

The Civil/Structural engineer by definition must be able to design simple structural components in steel and concrete, singularly and in a composite construction. The module seeks to engage students in the design of simpler structural forms, thus providing a sound base for design office practice during Industrial Placement and in readiness for the more complex final year module.

### Introduction to Combustion for Fire and Explosion Dynamics

This module is designed to provide a deep understanding of the fundamental physical principles underlying fire and explosion development. Particular attention is given to the chemical and physical processes associated with fire as a combustion system, fire chemistry and toxicity, fire initiation, growth and spread in open and enclosed spaces, deflagrations and detonations, blast waves and combustion in closed vessel.

### Human Factors and Behaviours

An understanding of human factors and behaviours is essential to ensuring the safety of occupants in buildings and the extended built environment. This module will address human factors relevant to the safety environment and behaviour in emergencies. It will also address the psychological impact of involvement in significant events. In particular, it will focus on the psychological and behavioural responses of individuals, groups and wider society relative to emergency situations.

## YEAR 4 (Final Year)

### Leading and Managing Emergency Response Teams

Emergency response projects are complex and highly demanding, involving a number of different and well coordinated courses of action. It is vital that these complex activities are well planned. Consequently, the success of aid projects in emergency response from planning through to the completion stage depends on the various parties' understanding of partnership and mutual trust and the common objectives that they share. The roles of parties involved in post-disaster reconstruction should be carefully arranged for the performance of reconstruction activities. Ultimately this module addresses the challenges of leading and managing people post disaster.

### Prevention through Design

Prevention through Design (PtD) also known as inherently safe(r) design is well established in the process industry. In civil engineering/construction, producing designs that are capable of being built, used, maintained and eventually demolished in a safe and healthy manner has been implicit in legislation since the Regulations were enacted to bring the EU Temporary and Mobile Workers Directive into force. PtD looks beyond the idea that reducing/ mitigating the impact of hazards is an issue for those who operate and manage facilities to the realisation that hazards need to be identified at the concept stage, addressed more fully at the scheme design stage and wherever possible/practical eliminated at the detailed design stage. This module delivers the knowledge and understanding and develops all the necessary skills to allow safety engineers to practice prevention through design.

### Structural Analysis and Design 4

This module is intended to prepare students to solve real structural engineering problems and combines complementary studies in structural analysis and structural design. Design is presented as an intellectual methodology and students are exposed to an environment, in which they experience the structural engineering design process. The design block encompasses the important stages of a full structural engineering design application, experienced within a comprehensive design exercise on a structural design set at a high professional level.

### Disaster Safety and Resilience

This module involves the identification and classification of extreme and hazardous events, the assessment and quantification of built (including infrastructure) and natural environment, vulnerability, robustness and resilience. The students are introduced to the provision of information on ecosystem values, human safety, shelter and utility provision in relation to design and scenario planning for man-made and natural extreme and hazardous events.

### Occupational Health and Safety Management

The focus of this module is on the policies and strategies, which influence health & safety management, and the relevant strategies to deal with the control of serious and imminent danger and major accidents. The importance of the social, political and economic influences on health and safety is also emphasised.

### Research and Dissertation

This Research and Dissertation module permits a student to develop further a particular element of the course and to apply investigative, analytical and personal management skills to an extended and in-depth academic study. This will enhance a student's competence in information retrieval, analysis, evaluation and report writing.

**Managing Safe Entry into Confined Spaces**

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ABSTRACT

In view of the number of recent accidents in confined spaces, many with fatal consequences, the need to effectively manage safe confined spaces entry has become one of the key focuses for the enforcement bodies on both sides of the Atlantic. Drawing on trans-global experiences this paper presents a management framework while examining the issues surrounding the provision of risk assessment, safe working procedures and permits to work. The paper also introduces the topic of measuring the costs of safety through the adoption of the Prevention-Appraisal-Failure (PAF) model, widely used in the field of quality assurance.

Key words: confined spaces, costs of safety, safety management system, risk assessment.

## INTRODUCTION

Many serious accidents have occurred whilst work is being done inside confined spaces. The chief hazards faced are those associated with toxic and/or flammable gases, fumes and vapours. Other hazards include the presence of free flowing solids, liquid
s and temperature extremes. Neglect or ignorance of the necessary precautions can lead very easily to tragic and often fatal results. In many cases the consequences extend beyond the workers inside the space to those who carry out unauthorised rescue attempts. It is widely accepted that over half of those who die in confined spaces would have been attempting to rescue work colleagues who had gotten into difficulties. For example, in three separate confined spaces incidents in the North of Ireland during 1995/96 there were seven deaths, accounting for almost 25% of the total deaths that resulted from accidents at work in that year. Of those seven deaths four of the victims were attempting an unauthorised rescue.

Many of these incidents, including their fatal consequences are destined to be repeated unless the management of safety in confined spaces working is developed to a high degree and practiced without favour by all interested parties. This paper sets out a management system incorporating trans-global best practice, which may be adopted to suit any jurisdiction.

## DEFINING THE CONFINED SPACE

The term "confined space" has a wide application throughout industry. In many instances confined spaces are fairly obvious, for example reaction vessels, enclosed tanks, large ducts and sewer pipelines There are others which are less obviously so, yet they are nonetheless equally as dangerous, for example open topped tanks and vats (particularly where heavier-than-air gases and vapours may be present), closed and unventilated rooms, and medium sized and large furnaces and ovens, in which dangerous accumulations of gases can build up as a result of restricted air circulation. The different national statutory safety bodies (NSSB) across the world will have their own form of words to define or describe confined spaces. However, while many of their definitions may be quite complex an acceptable generalised description of a confined space is that it is a workplace with one or more of the following characteristics;

a. limited openings for entry and exit,
b. unfavourable natural ventilation, or
c. has not been designed for continuous worker occupancy.

A confined space within the workplace having a combination of these characteristics will complicate the working and emergency rescue operations. If you are constructing or working in a CHAMBER, TANK, VAT, PIT, FLUE ,BOILER, DEGREASER, FURNACE, PIPELINE, PUMPING STATION, REACTION OR PROCESS VESSEL, SEPTIC TANK, SEWAGE DIGESTER, SEWER, SILO, SHIP'S HOLD, UTILITY VAULT, or similar type enclosure you are working in a confined space.

**SAFETY MANAGEMENT**

There is nothing that cannot be sorted with risk assessment and nothing that cannot be managed with co-operation is fundamental principle of any safety management system. It is particularly true in the field of confined spaces working where errors or infringements can lead to fatal outcomes. Safety management systems are identified as one of the key elements necessary to meet the goals of the USA Occupational Safety and Health Act of 1970. The strategy of the Occupational Safety and Health Administration (OSHA) in the USA is to pursue the following four strands;

a. Voluntary Protection Program (safety management system),
b. Consultation survey,
c. Full-service area offices, and
d. Effective enforcement.

Across the Atlantic the legislation in the Member States is driven by European Union (EU) directives. There is a clear requirement within the EU legislation to manage health and safety through the development of valid and effective risk assessments and associated risk control measures. Clearly, while the trans-global terminology may differ, the message and the spirit of enforcement remains the same. This is true for any aspect of workplace safety, however it is particularly poignant where confined spaces entry is concerned. The US Code of Federal Regulations (CFR) and the UK Confined Spaces Regulations demand proper and effective management of confined spaces working.

## COST OF SAFETY MANAGEMENT

Traditionally the costs associated with safety have been associated with the identification of workplace accidents and the incidental costs. Confined spaces accidents like any other workplace accidents have considerable human costs, affecting the workers immediate family, wider family circle and work colleagues. The death toll of 85 confined spaces fatalities across the USA in 1996 has the potential to impact dramatically and permanently on the lives of upwards of 2000 relatives. The numbers, although small relative to the USA working population, are totally unacceptable since with effective management deaths such as these are avoidable. Many of the intangible costs will never be measured but there are more obvious associated costs facing an organisation in this predicament such as, accident investigations, lost time, recruitment, worker retraining and legal penalties. These negative costs have the effect of associating safety with the measurement of failure. It is not surprising, therefore, that it is difficult to associate the company's safety department with improving its profitability. However there is a movement towards measuring safety performance much earlier in the process which stems from a recognition that there are significant cost savings to be gained by detecting non-conformance sooner. The reference to the fatal and costly effects of confined spaces accidents serves as a
reminder that for every act there is a consequence and often the consequence is too high a price to pay.

With the introduction of and adherence to effective and proactive risk control measures, such as competence based training, provision and use of appropriate safety equipment together with an auditable safe working procedure confined spaces deaths can be avoided. The costs of introducing prevention and appraisal will have to borne alongside the failure costs initially. In the longer term the failure costs will reduce as proactive safety performance becomes the company norm. An analogy exists between the costs of safety and the measurement of the costs of quality. One particular quality model, the Prevention-Appraisal-Failure (PAF) model looks at the quality costs within each of the categories, using a company-wide approach to quality improvement. With minor modification the PAF model can be adapted to consider the costs of safety to an organisation. In this situation the model may be used to advocate a move away from concentrating on failure costs such as workplace accidents, liability claims and lost time towards a renewed emphasis on prevention and appraisal costs. The target for quality improvements in the organisation's safety performance must be to raise the standards and to reduce workplace accidents within specified timeframes. This is achievable through the use of techniques such as;

a. safe working procedures (quality procedures),
b. risk assessments (process control), and
c. performance measurement (control of non-conformance).

The cost savings, in both financial and human terms, will serve to engender an enthusiasm for improvement throughout the organisation. This in turn should spread to other aspects of the business, thereby confirming the benefit of adopting costs of quality models as a means of achieving improved safety performance.

## KEY FEATURES OF SAFETY MANAGEMENT SYSTEMS

The test of any safety management system is in its documentation, however the documentation is only one element of a system designed to embrace the principles of quality and excellence in the health and safety field. There are three distinct levels required to create a safety management system; policy & organisation, procedures and documentation. A short critique of each follows.

### Policy & Organisation

A health & safety policy should be concise, comprising a general statement of intent and an explanation of how safety is organised within the organisation. It should detail how the safety system fits with the standards for occupational safety and health in areas such as;

a. how accountabilities are fixed,
b. how policy implementation is to be monitored,
c. what individuals health and safety responsibilities are and their associated accountabilities, and
d. what annual targets for health & safety and accident rate trends have been set.

### The Safety Procedures

This critical document details the procedures to be adhered to in order to ensure compliance with health and safety management. It has at its core a reliance on valid and complete risk assessments to determine the degree of control necessary to minimise risk. Risk assessment is a very real and practical concept in the management of occupational health and safety. It is not unique to confined spaces work but must be applied to all workplace activities as a means of assisting with the making of informed judgements on the likely consequence of one's actions.

Example: Safety procedures for confined spaces working should initially seek to avoid entry as the ultimate control measure. Failing that the worker must only enter confined spaces if they have been deemed competent and medically fit to do so and only after the emergency response arrangements have been confirmed and the pre-entry checks carried out. Depending on the nature of the hazard the control measures may also include, inter alia, the need for continuous atmosphere monitoring equipment, the use of breathing apparatus and permit requirements.

### Documentation

The safety management system requires supporting documentation such as confined spaces risk assessments, pre-entry checklists, competences certificates, permits to work and other records of the operation of the management system. These will form the basis of an audit trail which seeks to determine the extent of non-conformance and to identify areas with potential for improvement.

## INGREDIENTS FOR SUCCESS

The three essential ingredients for success of any management system are knowledge, behaviour and attitude within the workforce. If we can get them right then the effort required to reduce workplace accidents diminishes as staff work together in partnership to improve safe working practices. This is often referred to as a positive safety culture. It is essential that an organisation understands why it does the things it does. Indeed it is time that organisations moved away from the prescriptive "can't do" attitude, so prevalent in the safety profession in the past. A much more proactive and business oriented approach is called for which engages with positive management tools to ensure solutions are found which match the culture and discipline of the organisation. Within an organisation's safety management system risk assessments, audits and accident investigations must become the key management tools in accident reduction. It is best not to try and change behaviour by coercion. Although coercion can bring about temporary changes in behaviours, in many cases they will revert to the norm once the threat has been removed. The better option is to work on positive behaviour changes through leadership and good example. It has often been said that it is far easier to take hold of a piece of string and bring it along with you than it is to move it by pushing it from behind. This is certainly true in the case of health and safety where strong leadership and commitment from the top is more likely to engender positive behaviour changes.

## CONCLUSION

With knowledge and behaviour properly considered the attitude often takes care of itself. However it is worth remembering that a bad attitude to work does not in itself make a bad worker. Attitudes are the consequence of years of varying experiences and often can not be altered. Therefore, we must not get too caught up chasing rainbows, rather we can ensure positive results by applying the principles of total quality to heath and safety in the workplace. The objectives of any good safety management system is to reduce accidents or injuries in a cost effective manner through;

a. Senior management commitment,
b. High quality risk assessment based safety management systems,
c. Worker participation in safety improvements, and
d. Training programmes designed to increase manager and worker competences.

There are clear operational and financial benefits for companies who operate their business within structured and workable safety management systems. However for companies failing to address these issues properly there are legal consequences and considerable financial penalties to be faced. In the high risk area of confined spaces working it is imperative that companies take full cognisance of all the requirements of their own NSSB and put in place a comprehensive yet workable confined spaces safety management system. Such proactive measures will serve to reduce the number of confined spaces accidents and should eradicate the fatalities.

# Confined Spaces Working - Towards Zero Fatalities

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**Abstract**

In view of the number of confined spaces accidents still occurring in the 1990s, many with fatal consequences, the need to manage safe confined spaces entry effectively became one of the key focuses for the enforcement bodies across the world. Since 1993 specific confined spaces legislation has been introduced in USA, Canada, Australia, New Zealand and GB. Later in 1999, Ireland, north and south will have confined spaces law on the statutes. This paper draws on the authors' transglobal confined spaces expertise to examine the level of compliance, analyse the nature of confined spaces accidents and put forward a framework for eliminating fatalities in confined spaces.

**Key Words**

Confined spaces, dangerous atmospheres, accident analysis, violations, legislation, risk assessment.

**Introduction**

There should never be another fatality within a confined space. Technologically and intellectually we have it within our capability to prevent fatal accidents from ever occurring in confined spaces. Perhaps what is still needed is for industry to accept the managerial intricacies needed to propel us towards the achievement of that goal.

**Defining the confined space**

The term "confined space" has a wide application throughout industry. In many instances confined spaces are fairly obvious, for example reaction vessels, enclosed tanks, large ducts and sewer pipelines. There are others which are less obvious, yet they are equally as dangerous, for example open topped tanks and vats (particularly where heavier-than-air gases and vapours may be present), closed and unventilated rooms and furnaces/ ovens, in which dangerous accumulations of gases can build up as a result of restricted air circulation. Open spaces have , on occasions, become confined spaces by virtue of the prevailing conditions, aggravated by adverse weather conditions. Examples include; the vicinity of farmyard slurry pits, roof depressions and on top of chimney stacks.

The different national statutory safety bodies (NSSB) across the world will have their own form of words to define or describe confined spaces. However, while many of their definitions may be quite complex an acceptable generalised description of a confined space is that it is a workplace with one or more of the following characteristics;

- limited openings for entry and exit,
- unfavourable natural ventilation, or
- has not been designed for continuous worker occupancy.

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A confined space, within the workplace, having a combination of these characteristics will complicate the working and emergency rescue operations. If you are constructing or working in a chamber, tank, vat, pit, flue, boiler, degreaser, furnace, pipeline, pumping station, reaction or process vessel, septic tank, sewage digester, sewer, silo, ship's hold, utility vault, or similar type enclosure you are working in a confined space.

**Legislation and problems with compliance**

In the last quarter of the twentieth century considerable advances in safety legislation have been made on both sides of the Atlantic, with the Health and Safety at Work Act 1974 in the UK and the Occupational Safety & Health Act 1971 in the US as the parent legislation for standards, orders and regulations covering a wide range of hazardous work situations. Recent years has seen the introduction of specific Regulations that develop enforceable standards for confined space entry with 29 CFR1910.146 in the US and Confined Space Regulations 1998 in the UK. Similar Regulations come into force in the North of Ireland (NI) in June 1999 and in the Republic of Ireland at the end of 1999.

Since we do have the capability to prevent fatal accidents occurring, certainly within confined spaces, why do they continue to occur? Is it that standards are insufficient or somehow inadequate? Even if this was the case, and we do not argue that it is, there is still the intellectual capacity to analyse past accidents, and on the principal of foreseeability, design safe systems of work that ensure the safety of workers and public. Indeed there is a legal duty on employers to assess the potential risks in any work situation and to take appropriate steps to reduce those risks to the lowest acceptable level. Amputations, serious injury, debilitating health conditions and fatalities could hardly be considered the lowest acceptable level of risk. Are we to conclude that not enough consideration is being given to the hazards of work, or that safe systems of working are not being adhered to, for what ever reason. If that is so then it can be argued that accidents result less from an indeterminate compliance failure and more conclusively from compliance violations.

The Health and Safety Executive (HSE 1995) classified violations under four categories, routine, situational, exceptional and optimising.

Routine violations are those where it has become the norm to behave in opposition to the rule, for example through cutting corners, a general belief that the rule no longer is applicable or experienced managers/ workers feeling they don't need the restrictions. It is incumbent upon management to re-evaluate safety procedures on a regular basis and remove or change redundant procedures, however, enforcement of the rules must remain consistent and absolute until they are formally changed. Informal determinations that the procedure is no longer necessary, or that the worker is too experienced to need to follow the procedure cannot be excused. Such behaviour adds to a general dilution of safety consciousness with a consequent increase in the accident rate.

If left unchecked, routine violations become accepted practice which is then passed on to less experienced workers and new starts. While lack of enforcement by management implies tacit sanctioning of the violation there are occasions where managers ignore their own rules. A classic example happened a few years ago when a manager came upon an isolated water treatment site and found the chlorine supply low. Instead of calling on the operatives he set about the task of changing the chlorine gas cylinders, without any breathing apparatus. He had done it many times, it only took a few minutes, gas leaks were minor and besides he always held his breath at the crucial moment. On the day he last attempted this activity the pipework fractured and he was exposed to a high level of chlorine gas. It was his good fortune that a visitor to the site was able to effect a rescue.

Situational violations occur when factors in the immediate work space or environment affect the work process, making it impossible or extremely difficult to apply the safety rules. Example of this include the design and condition of the work area, time pressure, staff levels, supervision, equipment, weather and time of day. So where the demands of production and safety are in conflict often it is production that gets priority. In such circumstances violations may be sanctioned, not through neglect but cognitively to achieve productivity targets.

Exceptional violations occur rarely and usually when something goes wrong, tempting individuals to violate safety procedures in order to resolve the problem. These violations, generally associated with high risk, often result in accidents where a serious injury or fatality is the outcome. Skilled rescue workers are not immune from violations. There are recorded confined spaces incidents where rescue workers have died while trying to effect a rescue. It appears that in the urgency of the moment basic rules were ignored, the space was entered without the atmosphere being testing and that RPE was not available. This is testimony to the fact that when things happen suddenly and stress impinges, even experienced people can act in illogical ways (Larken 1998).

Finally, optimising violations are described as being motivated by a desire to optimise a work situation, for example in testing the boundaries of a system or simply through inquisitiveness.

HSE observed, correctly, that violations from whatever classification, when they are allowed to happen can quickly become routine. If it appears that routine violations have management sanction this could led to further violations in other areas, thus creating a downward spiral in safety standards.

Whatever the merits of the above classifications of safety violation, there are a number of key observations that can be made of all of them. Firstly, the violations are seen to be committed in the main by workers with a low level of employer culpability discerned. Where culpability is suggested at levels other than the violators' it is rarely made strong enough to take it beyond the first or second level of supervision or management. Secondly, by suggesting that routine violations are often automatically and unconsciously carried out, the classifications would appear to explain them in a manner that makes them understandable, possibly even excusable.

It has been a long established practice of health and safety inspectors to try to engender improvements in safety by persuasion rather than through strict enforcement methods. The thinking is that it is better to have employer support for safety than to have a hostile employer reluctantly and halfheartedly applying the minimum safety procedures. The US Occupational Health and Safety Administration (OSHA) are also attempting this through their Voluntary Protection Program (VPP) which they encourage employers to sign up to. HSE findings (1995) support the persuasion method although there is still much to be done at employee, employer, industry and enforcer level. Each of the distinct groups need to be able to work together, in partnership, to achieve what everyone publicly desires; a much reduced level of accidents in the workplace. Safety professionals have a facilitating role to play, using their expertise to help find workable solutions.

Enforcement authorities have and will continue to take stern measures when necessary. In the UK the more serious accidents and persistent failures to implement the terms of improvement notices have lead to prosecutions. However, the nature of prosecutions and the outcomes have often done little to further the HSE's cause or to satisfy the needs of victims of work related accidents. Dix (1997) argues that the UK courts are restricted in their sentencing options to applying a monetary fine to companies for safety failures. Where is the inducement to punish present and deter future failures, or even to rehabilitate company behaviour? It is virtually impossible to bring a prosecution against a company for manslaughter where a breach of safety obligations has resulted in a fatality, without first establishing that there is sufficient evidence to convict a senior company officer for the same offence (Dix 1997). The Lyme Bay canoeing accident is the only incident where such a prosecution has been successful. In the US several safety authorities, without negating the part played by employee behaviour and poor supervision, are arguing that compliance failures often result from more deliberate and conscious violations on the part of the company at a corporate level.

Notwithstanding the problems of under reporting of accidents, common on both sides of the Atlantic, many employers still seem to place short term savings over longer term benefits. Thus safety measures, including training are amongst the first to be cut when savings are required. This behaviour is more common amongst small to medium sized companies where safety costs are proportionately greater than those of large companies. In the absence of serious injury or fatality and for as long as companies can get away with it, there is the chance that their obligations to safety will not receive top priority. Karr (1999) reports that the low rate of reported accidents in the US, coupled with an inspection probability of once in every 66 years further promotes this ethos of short-cutting safety.

It is also argued (Karr 1999) that the strength of the economy is a contributory factor in compliance violations. The trade unions argue that whilst the economy is booming and competitive pressure is high, companies find it difficult to devote time to training and workplace safety. This would seem to imply excusability, with the priority on saving jobs. The increase in high technology operations that require fewer workers on very complex, often automated, equipment is a safety manager's nightmare.

High productivity + faster processes + complex equipment + fewer workers + deskilling = accident increase.

It must be remembered that the actions of the enforcement authorities directly effects the behaviour of companies. Targeting companies with high reported accident rates could have the negative effect of persuading some companies to deliberately under report. Clearly there is a need to maintain the balance between targeting campaigns and random inspections.

In US concerns have been voiced that the 'flavour of the month' approach to safety promotion leaves many companies only paying attention to the safety standard currently being enforced[1]. For example several years ago, when OSHA's confined spaces standard 29 CFR 1910.146 was the target for the enforcers, employers and safety consultants put a lot of energy into this area. Currently the emphasis is on the lock out/tag out standard, 29 CFR 1910.147, and reports are that employers are focusing less on the other elements of confined space safety. Indeed throughout the 1990s the confined space standard has not featured in OSHA's top 10 most frequently cited standards (Karr 1998). This is not because confined space safety has improved sufficiently that it no longer merits the

[1] Conversations between authors and US safety professionals at NSC Safety Expo, LA 1998.

attention of the enforcement agencies. Eighty seven fatalities in the US, in 1997, attributed to oxygen deficiency proves this.

**Accident Analysis**

Deacon (1997) argues that an organisation must maintain and further improve its contribution to overall business success through a recognised set of performance measures; economic, product/ service and personnel. Within each of these areas there is scope to integrate health and safety management such as;

- Economic including; uninsured costs, budget, insurance premiums and enforcement costs,
- Product/ service including; audit scores, benchmarking, safety awards and targets achieved, and
- Personnel including; accident and injury rates, dangerous occurrences and first-aid incidents.

It is not beyond the bounds of reason that an organisation should be more specific when setting its performance measures. For instance; where there has been a particular increase in a specific type of accident or injury or where audit scores demonstrate non-conformances in high-risk activities. This would be viewed as a responsible management decision for companies working with limited resources. After all HSE also have finite resources and they make no secret of the fact that they will target industries with poor safety records. It will always be to the benefit of an organisation that has the ability to demonstrate to HSE that it is taking all the necessary steps to improve safety performance.

Many serious accidents have occurred whilst work is being done inside confined spaces. The chief hazards faced are those associated with toxic and/or flammable gases, fumes and vapours. Other hazards include the presence of free flowing solids, liquids and temperature extremes. Neglect or ignorance of the necessary precautions can lead to tragic and often fatal results. In many cases the consequences extend beyond the workers inside the space to those who carry out unauthorised rescue attempts.

Baker (1986) reported that deaths in the UK due to confined spaces working accounts for 5 to 7 per cent of all workplace fatalities. In Canada, for every 1400 normal workplace accidents one results in a death yet where confined spaces working is concerned the ratio is one in ten (Ibbetson 1998). Confined spaces fatalities in the US, in recent years, have been in the order of 80 to 100 per annum[2] while in UK they have fallen from a high of 36 in 1986 to the present level of circa 5 to 10 per annum (Figure 1). With a population ratio in the order of 5:1 it can be assumed that the UK figures are marginally better, however there is no cause for complacency. Looking beyond the fatalities the major injuries statistics remain a source of alarm. For every confined spaces fatality in the UK over the last ten years 8 to 10 people have suffered the effects of exposure to harmful substances. The reasons why there have not been more fatalities is anybody's guess, however it would not be safe to assume that it is all down to good management. With effective safety management all exposures to dangerous atmospheres could be eradicated from confined spaces work operations.

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[2] Figures extracted from the US government's Bureau of Labor Statistics

Considering the number of confined spaces deaths and reportable injuries there have been in recent years a wise employer would treat risk control for such work activities as top priority. Granted there are other types of injuries and incidents within confined spaces but eliminating all life-threatening accidents before tackling any of the others must come first. Performance measures set to deal with the critical aspects of confined spaces safety must have zero fatalities and zero major injuries targets, particularly where immediately dangerous to life or health (IDLH) atmospheres are involved. It is entirely conceivable that in managing these critical safety aspects that many of the other issues will be addressed. For example the development and operation of an isolation (lock out/ tag out) procedure to prevent the ingress of dangerous atmospheres is no different, in principle, to that for isolating liquids, loose granular material or power sources. Consequently risk control systems to prevent drowning or engulfment can be in place without any additional effort or unnecessary resources.

Over the years some unusual and many more reasonably foreseeable incidents have occurred in confined spaces. Unfortunately fatalities, in particular amongst rescuers, are not uncommon events and often similar events end with the same tragic results. Tolley (1999) described an incident in 1959 where a doctor attempting the rescue of two workmen down a well was overcome by carbon monoxide fumes. Nearly thirty years later in NI an almost identical event resulted in the death of two would-be rescuers. While it might seem unreasonable to expect that everyone be conversant with the 1959 case, had the lessons and the transfer of the knowledge occurred the NI incident would have been foreseeable and avoidable. It is not possible to risk assess the unforeseen, however the telltale signs, often so obvious with hindsight, need to be highlighted and the lessons learnt if we are to break the cycle of repeat accidents. Foreseeability transcends company boundaries. One of the more unusual lessons of the Abbeystead explosion[3] was highlighted in the HSE report into the incident (1985);

"The fact that methane is soluble in water and increasingly so above ambient pressure, and that it can be given off by ground water entering workings, should be widely publicised throughout the civil engineering profession and incorporated in professional training".

Baker (1986) analysed the accident at Carsington Dam, where 4 young men died at the bottom of the reservoir toe drain, three of them while attempting a rescue. The consultant and the contractor were found to have failed in their duty to ensure the safety of the men who died. HSE in the 1970s produced a training film "Watch that space" which described how three men died in a drain in a construction site. Baker was struck by the uncanny resemblance of the circumstances depicted in the film to those of the Carsington accident. What does it take for the lessons to be learnt?

At Swan Hunter Shipyard in 1982 where an oxygen enriched environment created by the work activity resulted in an explosion which killed 8 men. The subcontractor had not been informed of the risk control measures and consequently the main contractor was prosecuted for failing to provide a safe system of work for subcontracted employees and for failing to provide information/ instruction so as to ensure their safety.

In three separate confined spaces incidents in NI during 1995/96 there were seven deaths, accounting for almost 25% of the total deaths that resulted from accidents at work in that year. Of those seven deaths four of the victims were attempting an unapproved rescue. The sentiments of the individuals compelled to act as they come upon their colleagues in

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[3] Sixteen people died and a further 28 were injured in that one incident

trouble is understandable, but had they followed approved safe working and rescue procedures they and the original victims might not have died.

Analysts and safety professionals tend to agree that for every death of a confined spaces worker at least one other person, often more, dies in a fateful rescue attempt. Ibbetson (1998) suggests that the ratio is two would-be rescuers for one victim. Human nature being what it is there will always be the 'have a go' hero who if successful will be praised for their bravery and if unsuccessful becomes another fatality statistic. It is necessary to be particularly hard on such behaviour, no matter how uncaring it may seem, since unsafe acts of this type endanger many lives.

An approved rescue procedure has to be an integral part of any safe working arrangement, since it is not always possible to accurately predict the outcome of a confined spaces work operation. Incidents will happen and have to be planned for in the normal course of events. The procedure could be as simple as an alarm and evacuation procedure or as complicated as a major incident plan. The nature and complexity of the emergency rescue arrangements will depend on the degree of risk involved. While there are many variations on the theme there is one fundamental principal that binds them, that is the safe exit of all workers from the space. Examples may include;

1. a standby worker outside the space, whose job it is to raise the alarm in the event of an incident occurring,

2. a dedicated rescue squad, fully equipped with self contained breathing apparatus, standing by with a full emergency rescue kit,

3. mechanical ventilation set to activate whenever the atmosphere monitor detects an IDLH environment,

4. the public emergency rescue services standing by throughout the confined spaces work operation.

Many of these incidents, including their fatal consequences are destined to be repeated unless the management of safety in confined spaces working is developed to a high degree and practiced without favour by all interested parties. A management system is needed, incorporating transglobal best practice, which may be adopted to suit any jurisdiction.

**Safety management**

Legislation within the European Union (EU) is driven by directives. Member States are bound to comply with EU directives within a specified time frame. UK legislation has a clear requirement for employers to manage health and safety through the development of valid and effective risk assessments and associated risk control measures. In the USA safety management systems are identified as one of the key elements necessary to meet the goals of the Occupational Safety and Health Act of 1970. OSHA's strategy is to pursue the following four strands;

1. Voluntary Protection Program (safety management system),
2. Consultation survey,
3. Full-service area offices, and
4. Effective enforcement.

So while transglobal terminology may differ, the message and the spirit of enforcement remains the same. This is true for any aspect of workplace safety, however it is particularly poignant where confined spaces entry is concerned. The US Code of Federal Regulations (29 CFR 1910.146) and the UK Confined Spaces Regulations demand proper and effective management of confined spaces working.

The best solution is to avoid 'confined spaces entry' work operations, if at all possible, however this is frequently not an option. Therefore what is needed is an effective safe working procedure developed on the sound principle of risk assessment. Remember that risk assessment need not be complex and that there are no fixed rules about how it should be done. What is important is that the level of detail it addresses is broadly proportionate to the degree of risk. There are probably as many different types of confined spaces as there have been fatalities in them and it would be implausible to expect a risk assessment to cover each and every one of them. For the more dynamic activities in UK and NI, where the detail of the work activity changes frequently, it is deemed to be acceptable practice to concentrate risk assessment on the broad range of risks that might arise (Health and Safety Agency NI 1992). Remembering that in the resulting safe working procedure (SWP) it is necessary to address the safety issues associated with entering individual confined spaces.

The safe working in confined spaces working will only truly be achieved when there is direct involvement, commitment and leadership from line management in the development of and administration of an effective SWP (Singleton 1998). The SWP must be written in a clear, concise and unambiguous manner and operated with a high degree of competence from managers and workers alike. The factors which will ensure success, discussed in more detail below, include;

- Confined spaces entry workers to be medically and physically fit,
- confined spaces training and assessment for worker and managers,
- management system, based on risk assessment principles, featuring pre-entry checks, permits to work (if required) and emergency rescue arrangements,
- regular safety inspections and audits with any violations dealt with swiftly and effectively,
- accidents to be investigated and lessons learnt to be shared both internally and externally within the industry, and
- risk assessments to be reviewed as part of any accident investigations.

Competence and supervision - The degree of supervision of confined spaces workers should be in direct proportion to their level of competence, therefore it is vital to have a system to determine, at the outset and at regular intervals, that the worker is both able and competent. Managers should be aware that an individuals level of medical and physical fitness can vary in between medical examinations. Any deterioration could adversely affect the safety of the workers and his colleagues while in the confined space. Competence is not determined simply by attending a training course, rather it something which needs to be assessed after training and at regular intervals beyond. It is also about knowing your limits so that, should the exceptional arise, you know what you can deal with as result of your own experience or expertise and when to call for additional assistance. If this is the case then the exceptional violations (HSE 1995) can be avoided.

The need to regularly check competence in the use of breathing apparatus, safe entry techniques and emergency evacuation arrangements is essential since there are people who only occasionally effect a confined spaces entry. When the time comes they need to be able to do so confident in the knowledge that they can deal with any foreseeable event. The manager can ensure their own familiarity with the procedures by becoming involved with routine competency checks.

Safe working procedures - While the experienced operative and manager of a manufacturing plant or construction site will possess a high degree of knowledge relating to the nature of hazards associated with confined spaces entry there will always be the potential for the unknown to appear. It is vital, therefore, that neither become complacent and let risk controls slip as a result. On new construction sites or manufacturing plants where conditions may not be fully understood there is need to ensure use is made of all available information such as, engineering drawings, working plans, and soil or geographical information. The general condition of the confined space, the work to be undertaken in it and any previous use or contents which could have led to adverse atmospheric conditions must also be considered.

The initial risk assessment will have considered the broad range of risks to determine the existence of high, medium and low risk areas and the basic level of controls. The worker making an entry and the project manager must jointly be satisfied that the conditions are right and the controls are in place at every entry. To achieve this a pre-entry check list is used, which allows the workers to consider each of the key safety features and to confirm that they are in place before proceeding. This should include; confirming the atmosphere is clear, confirming the condition and the presence of all the necessary safety equipment, determining whether a permit to work is required and ensuring that everyone knows the emergency arrangements. Permits to work should be used for high risk confined spaces where there is a known IDLH atmosphere or where isolations are required. OSHA Regulations 29 CFR 1910.146 defines 'permit required' confined spaces. Isolation may be required from hazardous fumes, electrical or mechanical power sources, liquids or heat sources.

Violations and non-conformances - Regular monitoring will establish whether violations are occurring, for whatever reason. They must not be tolerated under any circumstance since the procedures only exist because the work is potentially life threatening. Perpetrators of unsafe acts put their own lives, the lives of their colleagues and the lives of the emergency services personnel at risk. This can not be ignored. Safety audits, on the other hand, will regularly examine the effectiveness of the SWP. The frequency of the audit will depend upon the nature and complexity of the work operation. The auditor will identify any weakness or non-conformances and will determine how quickly they need to be addressed.

Accidents - Accidents are human failures and no matter how careful we are there is always the possibility that an accident will occur. What is important is that any accident is investigated in a professional manner, systematically examining root causes and determining the learning points. This will only be successful if carried out in a 'no blame' culture where everyone is encouraged to discuss the short comings. Included in any accident investigation should be an examination of the effectiveness of the risk assessment and the control measures. Workers and managers need to be informed of the outcomes in order to prevent a reoccurrence. It would add to the safe working of other companies if the more unusual accidents and their findings were reported widely. This could be done, after removing commercially sensitive information, through professional/ trade journals, association meetings and very effectively on the internet. It is only through learning the lessons from accidents and incidents that we will truly be on the road to zero fatalities.

**Costs of safety management**

Traditionally the costs associated with safety have been linked to the identification of workplace accidents and the incidental costs (McAleenan and McAleenan 1998a) . Confined spaces accidents like any other workplace accidents have considerable human costs, affecting the workers' immediate family, wider family circle and work colleagues. For instance the death toll of 87 confined spaces fatalities across the USA in 1997 has the potential to impact dramatically and permanently on the lives of upwards of 2000 relatives. The numbers, although small, relative to the USA working population, are totally unacceptable since with effective management such deaths are avoidable.

Work related fatalities, injuries and ill health continue to cost the world economy billions every year[4]. The HSE estimates that businesses in the UK lose upwards on £9bn, annually, through lost production, insurance and compensation. The Trade Unions Congress (TUC) has further estimated that this figure could be doubled if consideration is given to the true loss of income suffered by the victims of workplace accidents (Tolley 1997) coupled with the additional costs passed onto consumers through higher prices. The Eurostat figures rank the UK as having the third lowest accident rate in Europe (IRN/ HRM 1998). The US National Safety Council has estimated that in 1997 work related death and injury cost the country $127.7bn (Karr 1999). The major western economies, it

[4] Injuries at work cost the equivalent of £21 a week for each British family.

seems, are expending more on accidents or compliance failures than the GDP of the majority of countries in the world (Economist 1998)[5].

Whilst strict comparisons cannot be made between the US and UK on these figures alone, it is abundantly clear that safety management failure is a very costly business.

Many of the intangible costs will never be measured but there are more obvious associated costs facing an organisation in this predicament such as, accident investigations, lost time, recruitment, worker retraining and legal penalties. These negative costs have the effect of associating safety with the measurement of failure. It is not surprising, therefore, that it is difficult to associate the company's safety department with improving its profitability. However measuring safety performance much earlier in the process will deliver significant cost savings by detecting non-conformance sooner. In the longer term the failure costs will reduce as proactive safety performance becomes the company norm. It is widely acknowledged in the quality field that for every £1 spend on quality improvement can net up to £7 in saving. If we apply this to the safety business on the macro level then NSSB spending on improving enforcement could significantly reduce the cost burden on the economy. In the UK for example, it would take an investment of £2.3bn to eliminate the £16bn cost of accidents (Davies and Teasdale 1994). Just imagine the effect a £2.3bn cash injection would have on safety enforcement.

The number of fatal and near-fatal confined spaces accidents is a reminder that every act has a consequence and often the consequence has too high a price to pay. McAleenan and McAleenan (1998b) argue that the objectives of any good safety management system is to reduce accidents or injuries in a cost effective manner through;

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[5] In 1998 only 30 countries had a GDP greater than $130bn.

- Senior management commitment,
- High quality risk assessment based safety management systems,
- Worker participation in safety improvements, and
- Training programmes designed to increase manager and worker competencies.

There are clear operational and financial benefits for companies who operate their business within structured and workable safety management systems. However for companies failing to address these issues properly there are legal consequences and considerable financial penalties to be faced. In the high risk area of confined spaces working it is imperative that companies take full cognisance of all the requirements of their own NSSB and put in place a comprehensive yet workable confined spaces safety management system. Such proactive measures will serve to reduce the number of confined spaces accidents and should eradicate the fatalities.

**Conclusion**

Violations that occur across all industry sectors are the product of a number of factors including; employee behaviour (the result of inadequate training and supervision), and avoidance of safety procedures by companies in the pursuit of increased productivity or the retention of market positions. Thus in all regards, violations are the responsibility of the company, the corollary of which is that compliance and compliance management is a corporate function. Safety and quality are not irreconcilable concepts. Poor quality procedures could causes safety failures and poor safety procedures will reflect negatively on quality. In partnership, safety professionals and the managers of quality procedures can and should be designing safe systems that are commensurate with the work to be done. Compliance with safety requirements can be forced, but when led from the top with executive direction, competent line management and skilled worker input, safety becomes a natural and accepted practice in the workplace. There should be no need for aggressive enforcement.

It is this approach that should be encouraged by the enforcement agencies. Aggressive enforcement can and often does create a culture of "enforcement shadowing", with systems being put in place simply to avoid being caught out, and being dropped when the attention of the enforcer turns elsewhere. If we are promoting the integration of safety and quality procedures within the workplace, then contiguous with this is the national management of compliance by the enforcement agencies via a similar integration of national safety and quality standards.

Resource limitations mean that enforcement agencies are obliged to target those areas with the apparent highest accident rates. There is an analogy with the plate juggler in the circus who manages dozens of plates spinning on top of poles. He does not wait until a plate crashes to the floor before tuning his attention to it but rather continually keeps his attention on all of them. He moves between them supporting each with a nudge as required. Similarly in industry and at national levels, safety can be managed by paying attention to all parts and supporting those areas that show signs of wobbling. When the plates begin to fall the time taken to clear the damage and start a new plate spinning is time away from managing the other plates so they in turn fall. Time repairing the damage of major compliance failures is time away from managing safety elsewhere. If safety is not being properly managed more failures occur. Proper resource management coupled with judicious short term investments will net long term benefits with employers and NSSBs able to meet their safety obligations.

Aggressive enforcement is required when there are deliberate and malfeasant violations of safety standards in order to meet the demands of production, efficiency savings, or when negligent management causes or has the potential to cause serious injury, fatality or destruction. This is not a negation of the argument that good management flows from the willingness and acceptance, by all, of the need for quality procedures, but is the warning behind the system that failure carries with it severe consequences.

If we are going to achieve zero fatalities and zero major injuries in confined spaces then we need to put a stop to violations, learn the lessons from past accidents and improve our safety management.

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# Safety - Turning the event into a process.

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## Abstract

Roads Service is an agency of the Department of the Environment for Northern Ireland, responsible for over 24,500km of public roads. Roads Service's unique position in the United Kingdom and Ireland as the region's sole road authority gives it the ability to implement consistent and cost-effective practices.

Roads Service's overall aim is to ensure the provision of a safe and effective road network throughout Northern Ireland (NI), recognising the need to protect the quality of the environment.

Roads Service employs 1035 professional, technical and administrative staff and 950 direct labour workers. The workforce is involved in a wide range of work activities, each with its own particular hazards and risk control measures. It is important, therefore, that the safety controls identified through risk assessment are implemented in a way that promotes an improved level of safety across the organisation.

Since 1997 Roads Service has completely revised its approach to safety. The resulting system, embracing many of the principles of the International Quality Standard (ISO9000), is exceptional within the NI public sector and perhaps even within NI industry. This paper addresses the many positive aspects facing an organisation taking this approach.

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**Key Words**

Accident reduction, Partnerships, Plain speaking, Quality approach, Safety management systems.

**Introduction**

Milne (1926) introduced a character with a profound insight into modern management thinking (see inset). Notice that in Milne's opening paragraph health, safety and welfare is high on the agenda, if only time could be made available to deal with the issues.

> "Here is Edward Bear, coming downstairs, bump, bump, bump, on the back of his head, behind Christopher Robin. It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there really is another way, if only he could stop bumping for a moment and think of it"
>
> Opening paragraph from AA Milne's "Winnie-the-Pooh"

This paper describes how the Roads Service took a 'moment' to think about a new approach to safety management, taking account of current industry best practice.

**Health and Safety Legislation since 1974.**

For many companies, coming to terms with the requirements of the Health and Safety at Work (HASAW) Act 1974 or the HASAW (NI) Order 1978 has meant a long period of learning. Perhaps it would be more accurate to say that it took a long time to develop an understanding of the main requirements of the health and safety legislation.

One of the key concepts in the production of the new HASAW legislation was the desire to replace the mass of existing legislation with one single Act that would apply to all workers. The key obligation for employers was to be aware of all the risks associated with

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their industry and to put in place sufficient risk control measures to protect the workforce. While the principle was sound, the practice and degree of compliance varied significantly across the country and across the different industry sectors.

The development of a Single European Market in the early 1990s brought more challenges. Differing standards and legislative requirements across the member states were so significant that the potential for cross-community competition was seriously impaired. There was a clear need for the European Union to address the issues raised by this situation and at the same time give a renewed impetus to the direction that health and safety should be taking.

The harmonisation of European health and safety legislation was accomplished through a framework of directives aimed at covering all risks associated with workplace health and safety. The implication for the UK was the 1993 Management of Health and Safety at Work Regulations (MHSWR) and the related regulations[1], collectively and colloquially known as the '6 pack regulations'.

The direct effect of European intervention was to make explicit that which had been implied in the original HASAW legislation. In particular, the new legal requirements placed risk assessment at the heart of health and safety management and gave it legal backing.

[1] The related Regulations are; Provision and Use of Work Equipment, Manual Handling, Workplace (Health, Safety and Welfare), Personal Protective Equipment and Display Screen Equipment.

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**Public Sector Response**

The public sector always considered that it should give a lead in complying with the HASAW legislation. This was done through the production of detailed safety policies and the development of safe systems of work relating to all workplace hazards. Over the years there has been the fear that compliance with the HASAW legislation could not be guaranteed unless everything was carefully documented and nothing was overlooked. The net result was that volumes of paper were created as a means of defence. This proved to be counter-productive, since it was not always logical or cohesive and was very difficult for the end user to assimilate.

Recently a more practical approach has developed which has seen a trend towards managing safety in line with an accepted management model. As the public sector comes to accept this position the fear has subsided and organisations have grown more confident in their ability to manage safety within the requirements of the European framework.

**Merging quality and safety**

In the 1990s many forward looking companies adopted strategies to achieve business excellence and world class performance. They used total quality management (TQM) to develop and support an integrated approach to business management. It has only recently been realised that there is a need to apply the TQM principles to other aspects of the business. As a consequence the notion of fully integrating quality, safety and environmental management systems emerged.

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In 1997 Roads Service recognised the need to revise its current safety management system, which had been developed in the early 1980s. The existing arrangements were a collection of safety circulars, hazards warning notes and safe systems of work. Much of the dissemination of information was reactive, often dealing with specific legislative requirements. In order to derive the benefits from a more cohesive and comprehensive system Roads Service grasped the opportunity for a radical improvement of health and safety management, using appropriate continuous improvement tools (Juran 1986). Juran's methodology is widely used throughout the Northern Ireland Civil Service (NICS) to improve its business processes.

Using guidance from the UK Health and Safety Executive's (HSE 1997a) and the British Standards Institution (BSI 1996) a safety manual has been produced, embracing many of the values of the International Quality Standard ISO9000. The new safety management system integrates quality and safety in a way that provides clear and concise guidance to all of Roads Service's employees. It places at its core the need for suitable and sufficient risk assessments to determine the degree of control necessary to minimise the risk. Juran (1986) defined a quality product or service as one that is fit for purpose from concept to disposal. Adapting this definition to the development of safety management systems reflects Roads Service's firmly held belief that health and safety advice should not only address the physical and mental welfare of its employees but also the financial well being of the Service. This way a strong and successful future is assured.

Many organisations work to the principles laid down in HSE's health and safety management guidance. Roads Service's integration of quality and safety has allowed it to produce a safety management system that is the first of its type in the NICS and possibly even within NI industry. Clearly there is a balance to be struck between the effort

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expended and the level of improved safety performance achieved. The 'law of diminishing returns' applies. Roads Service believes, therefore, that the degree of detail should be the minimum required to achieve the optimum level of safety within the organisation. This approach ensures that resources are directed in a measured proportion across the risk spectrum[2]. This means that managers and the workforce can easily understand the key requirements.

**Importance of Correct, Up-to-date Information**

Implementing safety measures and systems costs a considerable amount of money, but even though Roads Service's accident rates are no greater than the sector norm, failures in safety remain a significant cost both in financial and human terms. The total number of accidents in Roads Service, including non-RIDDOR accidents, is approximately 150 per year (McAleenan 1998). On average this results in 2400 lost workdays which costs Roads Service approximately £135k per year in lost wages. There are many other associated costs to be considered such as down time, staff cover, accident investigation and procedures reviews. Conservative estimates suggest that they could be in the order of five times the wages bill (HSE 1997b) which, if taken together with the cost of employers liability claims, brings the total yearly cost of accidents (failure costs) to around £1.1m. Even if the improved safety management delivers only a 10% reduction in the accident rate, Roads Service could accrue savings of around £100k per year, not to mention the considerable savings in human terms.

Roads Service has set its accident reduction target at 10% over a three year period realising, however, that there is scope to effect even greater efficiencies through careful

[2] The risk spectrum spans from the low risk areas within the office environment through to the high risk areas such as motorway maintenance and confined spaces entry

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targeting of resources. Loosely applying the Pareto Principle would suggest that 80% of accidents will fall within 20% of work activities and that 20% of accidents could give rise to 80% of the costs. The tools are available to establish the critical few areas where most accidents occur and the capability exists to use the information to force the trend further downwards. What is required beyond that is the will to tackle these issues head-on.

Over time the cost of accidents and injuries, lost time and liability claims will reduce as the more proactive safety measures come into effect. The intention is that the savings should be directed towards prevention and appraisal matters such as:

- Risk assessment,
- Workplace inspections,
- Training, and
- Audits and Reviews.

Over the years the Roads Service accident rate has been dropping steadily, having its last major downward turn after the introduction of risk assessment early in the 1990s. The time is right for a renewed impetus to steepen the decline still further. This will only be achieved by concentrating on the highest areas of risk within the risk spectrum. The accident rates statistics since 1994 are presented in Figure 1.

**Key features of safety management systems**

Jackson and Ashton (1993) indicated that the test of any management system is in its documentation. However documentation is only one element of a system designed to embrace the principles of quality and excellence in the health and safety field. There are three distinct levels required to create a safety management system; policy & organisation,

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safety procedures and documentation.

Policy & Organisation - A health & safety policy should be concise, comprising a general statement of intent and an explanation of how safety is to be managed within the organisation. It must detail how the safety system fits with the standards for occupational safety and health in areas such as;

- Who is responsible for health and safety at various levels,
- How these responsibilities are allocated,
- how policy implementation is to be monitored, and
- what annual targets for health & safety and accident rate trends have been set.

The Safety Procedures - This crucial document details how the organisation will ensure compliance with health and safety legislation. It relies primarily upon suitable and sufficient risk assessments to determine the necessary risk control measures. The document may be classified into safety management and safe working procedures. All the procedures are produced in a common format, modelled on the quality assurance procedures of ISO9000, under the headings;

- Title.
- Purpose - background and objectives.
- Scope - persons or work areas affected.
- Definition - any necessary technical jargon.
- Procedures – short, numbered, bullet points/ charts or graphs.
- Responsibility - which staff member/ group has responsibility.
- Documentation - forms, control sheets etc. which make the system auditable.
- References - related procedures, instructions and guidance.

Documentation - The safety management system requires supporting documentation such as risk assessments, control sheets and records of the operation of the system. These documents form an audit trail, which seeks to determine the extent of non-conformance and areas with potential for improvement, thereby closing the feedback loop of the management system.

**Management and employee ownership**

No system will ever succeed without buy-in from senior management and the staff. The challenge facing the architect of any health and safety management system is to establish and maintain a balance between these two, sometimes conflicting, interests. The objective must be the development of quality-based safety system that encourages total employee involvement in the safety management process.

Before developing the new safety management system Roads Service conducted a targeted sample survey in July 1997 across all disciplines, grades and business units. The survey examined deficiencies in the current arrangements and sought respondents' views on what features and information would be required. The survey indicated a high level of dissatisfaction with the current arrangements, citing them as unwieldy, unprofessional and often too detailed. There was an overwhelming desire for documentation that is clear, concise and accessible to all staff. The suggestion of an electronic version of the documentation received widespread approval and will be introduced to the Roads Service Intranet in the coming months.

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It would be fair to say that Roads Service's new approach to safety management has been designed with impact in mind. It uses plain english in a concise manner and supports this with challenging graphic illustrations. While reaction to the artwork has been varied there can be no doubt that it has sparked some interesting debate. When employees are stimulated to discuss the design of a safety manual it means that they are more likely to open and read it than to put it in a drawer. So begins the process of integrating safety matters into everyday thinking.

The new approach is as much about ensuring that safety does not become a single event but rather that the whole process becomes enjoyable and eventful for all concerned. Consequently the revised safety management system contains the following key elements:;

- a new safety manual,
- a simplified approach to risk assessment (also available on the intranet),
- a new pocket safety book, and
- a safety awareness campaign for all current and future staff.

There was wide consultation during the production of the pocket safety book. The general consensus was that it really should be pocket sized and present the information in a simple, 'do-don't', format (Figures 2 & 3). The success is evident in the fact that it has rapidly become the first point of reference for most employees requiring safety guidance.

**Ingredients for success**

The essential ingredients for success of any system are knowledge, behaviour and attitude within the workforce. If we can get these right then the effort required to reduce workplace accidents lessens as all staff work in partnership to improve. Often referred to as a positive safety culture, it is about an attitude of mind that promotes co-operation

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across grades and disciplines within the organisation.

In order to survive in a competitive marketplace it is essential for a business to have knowledge and understanding of why it does the things it does. It is time for a move away from the 'can't do' attitudes, so prevalent in the safety profession of the past towards a proactive business-oriented 'can do' approach. It is very important to use positive management tools to find solutions (such as risk assessments, audits and accident investigations) that match the culture and discipline of the organisation.

It is best not to attempt behaviour change by coercion. While that can bring about temporary changes in behaviour, it often reverts to the norm when the threat has been removed. The better option is to work on positive behaviour changes through leadership and good example. It is far easier to move a piece of string by taking hold of one end and bringing it along with you than it would be to push it from behind. This is certainly true in the case of health and safety where strong leadership and commitment from the top is more likely to engender positive behaviour changes.

When knowledge and behaviour is properly considered the attitude often takes care of itself. However it is worth remembering that a bad attitude to work does not in itself make a bad worker. Attitudes are the consequence of years of varying personal experiences and often can not be easily altered. So the temptation to get caught up chasing rainbows should be avoided. Instead, positive results can be ensured by applying the principles of total quality to health and safety in the workplace.

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**Roles and responsibilities**

The safety advisory officer has played a central role in safety management within Roads Service since the enactment of the HASAW legislation. It is now recognised that safety management is not something that can be left to those few individuals, but something for which every employee, from the top down, has a responsibility. The new approach is quite different to what the Service has been used to over the years, but it is an approach that is needed for the safety strategy to be successful.

The safety manual clearly defines the key tasks and major outputs for everyone within the organisation; policy makers (at boardroom level), planners (all managers) and implementers (the workforce). Additionally each safety procedure details who is responsible for their successful execution. Any new system causes concern among those who have to use it, but in this case nobody lost control or gained any additional responsibility, rather the roles have just been more clearly defined.

The approach adopted is in line with thinking at the highest levels within the NI Health and Safety Inspectorate and in the Health and Safety Executive in GB. The safety advisory role of giving clear and succinct professional advice whenever it is needed remains crucial to the success of the new approach.

Roads Service has high expectations for the success of their new system but experience shows that;

SUCCESS = RESULTS – EXPECTATIONS.

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In other words success is only recognised when results exceed the expectations. So if success is to be achieved then high expectations must be met with excellent results.

**Partnerships to success**

Roads Service strongly believes in the value of partnerships to achieve quality improvements. Within the field of health and safety Roads Service has partnerships at many levels both inside and outside of the NICS. The most notable partnership within NICS is that with its sister organisation, the Water Service, since both services have many of the same opportunities for improvement. Roads Service has also developed and maintained a close liaison with the Health and Safety Inspectorate throughout the production of its safety management system. These have been invaluable and will continue for many years to come.

External partnerships include liaison with the UK highways authorities on matters of mutual interest and working with the Construction Employers Federation and other client bodies to improve the safety performance of NI contractors.

Important though all these partnerships are, Roads Service will only achieve its target of reducing workplace accidents if all the staff work together in partnership. The search for improvements in working methods is everyone's responsibility and ideas for improving safety are always worthy of consideration whatever the source.

Implementing a health and safety management system based on sound management principles and having a track record of improved safety performance is a legal requisite that is increasingly being viewed as a positive factor in business success. This approach reflects the value of the worker to the organisation and accepts that protecting the employee is the right reason to 'do safety'. Employees who feel valued are inspired to work for the success of the organisation. Roads Service accepts this thinking and is actively seeking health and safety benchmarking opportunities, with like-minded organisations, in an effort to achieve business excellence.

**Conclusion**

Manning (1998) said "One of the most dangerous things you can do is show up for work!" He is right that work can be a dangerous place. However, it is our responsibility to ensure that no matter how dangerous the working environment is our workforce is not harmed by it. This we must do through an assessment of the extent of risk and the production of clear and concise risk control measures.

There is a need for plain speaking in the way that the safety message is communicated to all employees. In producing its safety management system Roads Service has honoured its guiding principle; to keep the degree of detail at the minimum needed to achieve the desired level of safety. Safety can not be treated as an event or a series of single events spread across the working year. It is a thought process within each of us that can and should be reinforced through the production of original and thought provoking material.

This paper has presented some ideas for managing safety, which although logical are still deemed to be quite radical. This fresh approach has received broad support within Roads Service and its adoption has certainly changed how management and staff view safety management. Change is never easy to accept but often it is inevitable and in this case the changes outlined are to be welcomed.

The challenge remains for all the leaders in Roads Service, to ensure that the changes on paper translate into positive changes on the ground.

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Title Page:

Session 954: Confined Spaces Certification and Licensing Program

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## Abstract

There should never be another fatality within a confined space. Technologically and intellectually we have it within our capacity to prevent fatal accidents in confined spaces from ever occurring. This paper makes the case for licensing and certifying confined spaces entry workers and their managers on the basis of proven ability to use all the necessary safety equipment to the required standard of competence and to execute a confined space entry using all the proper precautionary methods. It is not argued that this alone will save the life of every confined spaces worker but the authors would strongly submit that it is the linchpin of any confined spaces entry management system.

The paper is based on experience gained from the operation of a licensing and certification program for confined space entry workers in Ireland over a number of years. At the time a program has started to train, assess and approve CSPs in the US to deliver a similar program to confined spaces entry workers during 2000.

The Irish statutory training agency (FAS) and Grupa Traenala Naisiunta na Seirbhisi Uisce (Water Service National Training Group) are in the process of setting up a pilot program to test the efficacy of a similar approach.

## Introduction

Investigating a confined spaces incident in Brazil, engineer Francisco Kulcsar Neto found that the company, a metallurgical plant outside Sao Paulo, had no knowledge of the hazards workers faced in confined spaces. In Ireland, during a safety compliance audit it was discovered that while the organization was fully cognizant of the hazards associated with confined spaces, workers, on the ground, were not so aware.

These are but two examples that illustrate the awareness deficiency in respect of confined space safety. Many similar examples can be used to illustrate that where companies and employees have a poor awareness of confined space hazards competence in confined space safety fails, and when it fails it fails with tragic consequences, (McAleenan & McAleenan 1998 (a)). Furthermore, many fatalities involve personnel attempting to rescue colleagues who had collapsed or had gotten into difficulties, illustrating the fact that unplanned rescue attempts by untrained personnel add to the tragedy.

This paper will examine the consequences of accidents in the US and explore the need for a more sophisticated methodology to ensure that training adds to the competence of workers and companies.

## The Social Costs of Confined Space Accidents in the US

Building a comprehensive picture of confined space accidents involves abstracting information from a range of sources and placing them in a context which makes sense of the figures and highlights the failings that give rise to the incidents in the first place.

Work-related unintentional fatalities in the US, have fluctuated between 5,000 (1996), 5,150 (1997) and 5,100 (1998), whilst disabling injuries[1] have risen from 3.8 million in 1997 to 3.9 million in 1998 (Hoskins 1998, 1999)[2]. OSHA statistics for all work related deaths show a higher figure of 6,218 fatalities in USA private industries in 1997 (6,112 for 1996). The following information has been extrapolated from the OSHA figures. Of the 6,218 fatalities in private industry, 424 (6.8%) were the result of confined space related accidents or accidents of a similar nature (Table 1 illustrates).

| Event or exposure | Total (No.) | Private Industry (percent) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Agriculture forestry fishing | mines | construction | manufacturing | transport utilities | wholesale trade | retail trade | finance insurance real estate | services |
| **Contact with objects & equipment:** 1035, of which | | | | | | | | | | |
| caught in running equip. or machinery[3] | 189 | 26.5 | 5.8 | 9 | 41.3 | 5.8 | 5.8 | | | 3.7 |
| Excavation or trenching cave-in | 35 | | 8.6 | 74.3 | | | | | | |
| Other cave-in | 5 | | 100 | | | | | | | |
| | | | | | | | | | | |
| **Exposure to harmful substances:** 550, of which | | | | | | | | | | |
| exposure to environmental heat | 22 | 27.3 | | 27.3 | | | | | | |
| Inhalation in enclosed, restricted or confined space | 25 | 20 | | 28 | 16 | 12 | | | | 12 |
| Inhalation in open or other non confined space | 19 | | | 42.1 | | | | | | 21.1 |
| oxygen deficiency | 87 | 21.8 | 3.4 | 11.5 | 11.5 | 8 | | 4.6 | | 10.3 |
| depletion of oxygen in other enclosed, restricted or confined space | 5 | | | | 60 | | | | | |
| **Fires and explosions:** 196 of which | | | | | | | | | | |
| explosion in pressure vessel | 37 | 16.2 | 13.5 | 8.1 | 24.3 | | | 8.1 | | 10.8 |
| **Total** | **424** | | | | | | | | | |

**Table 1: Fatal occupational injuries by event or exposure in major private industries, 1997**

Although not all of these fatalities occurred in confined spaces, there is sufficient similarity in the description of the incidents to confined space incidents to make an educated guess that a high percentage have been in that area. What is certain is that the fatalities occurred in high-risk environments.

Confined space environments present a higher fatality risk than other high-risk environments. In Canada for every 1400 normal workplace accidents, one results in a death, but where confined spaces are concerned the ratio is one death per ten accidents (Ibbetson, 1998). Applying these ratios to the USA, 6,218 fatalities equates to over 8,705,000 accidents annually. Alternatively, there are over 117m employees in US. An average accident incident rate of 7.1 (Table 2) per 100 workers would suggest circa 8.5m accidents per year. On average there are 20 people directly affected by each work related death. In this respect, some 1.2 million, partners, children, family and friends, are affected each year by the deaths of people at work. This is the human cost.

Analysts and safety professionals tend to agree that for every death of a confined space worker at least one other person, often more, dies in a fateful rescue attempt. Ibbetson (1998) suggests that the ratio is two would-be rescuers for one victim. Extrapolating from the statistics on confined spaces fatalities, there may be as many as 4,240 confined space related incidents each year. The human costs, affecting the workers' immediate and wider family circle in the 424 confined space and high-risk environment fatalities across the US in 1997 will have had a dramatic and permanent effect on the lives of upwards of 8,480 people. The numbers, although small, relative to the US working population, are totally unacceptable since, with effective management and training, such deaths are avoidable.

Traditionally the costs associated with safety have been linked to the identification of workplace accidents and the incidental costs (McAleenan and McAleenan 1998a) but the human cost of fatalities is greater than the dollar figure.

## The Economic Costs of Confined Space Accidents in the US

Table 2 illustrates the incident rates for the number of injuries and illness per 100 workers in a range of private industry sectors. In 1997 this accounted for 3.8 million disabling injuries.

| Industry (Private Industry) | injuries and illness Total cases | injuries and illness with lost working days |
|---|---|---|
| Private industry | 7.1 | 3.3 |
| Agricultural production, livestock | 11.4 | 5.5 |
| Forestry | 6 | 2.9 |
| Mining | 5.9 | 3.7 |
| Construction | 9.5 | 4.4 |
| Manufacturing | 10.3 | 4.8 |
| Textile goods etc. | 11.5 | 4.2 |
| Lumber & wood products | 13.5 | 6.5 |
| Chemicals & allied products | 4.8 | 2.3 |
| Rubber & misc. plastics products | 11.9 | 5.8 |
| Primary metal industries | 15 | 7.2 |
| Fabricated metal products | 14.2 | 6.4 |
| Industrial machinery & equipment | 10 | 4.1 |
| Transportation equipment | 15.4 | 6.6 |
| Misc. manufacturing industries | 8.9 | 4.2 |

**Table 2: Incident rates for injuries and illness per 100 workers in private industries.**

The overall incidence rate for private industry is 7.1 per hundred workers, with many sectors above 10. Approximately half the incidents led to lost days or reduced time accounting for the 3.8 million figure above. These disabling injuries have resulted in 125 million lost days each year with an anticipated further 60 million future lost days (Hoskin 1998, 1999). This is the industrial loss.

Overall, accidents cost the USA economy $127 billion annually (Karr 1999(a))[4], a figure greater than the GDP of the majority of countries in the world. (The cost of accidents at work in the UK is some £20bn, and in Australia A$27bn.). The major western economies, it seems, are expending more on accidents or compliance failures than the GDP of the majority of countries in the world (Economist 1998)[5].

## The Legal Implications of Confined Space Accidents in the US

Accidents prompt OSHA inspections. Where inspections have taken place, particularly in response to injurious or fatal incidents, the employer can expect to be prosecuted. For example, in 1997/98 102,638 OSHA citations were issued against all industries, of which 7,348, (7.2%) were in respect of confined space and RPE violations. As a result penalties totaling $82 million were imposed ($5.6 million re. confined space and RPE violations), an overall figure falling far short of the $127bn that accidents cost the US economy each year.

In the 1990s OSHA inspections and enforcement resulted in some $500 million in fines in respect of more than 600,000 violations. Seventy-six cases of egregious violations each resulted in over $1 million fines, and a further 786 cases exacted fines greater than $100,000 (Karr (c) 1999).

The penalties, associated with successfully prosecuted cases, bear little resemblance to the social and economic impact that unintentional workplace injury and deaths have on the nation. However companies, so prosecuted, are open to civil suits taken by the injured parties, as are those who may not have been guilty of any violation but are none the less liable for injuries done to their employees. Furthermore, employers may be held criminally liable for fatalities in their work place and as a consequence of US vs. Pitt-Des Moines Inc. (1993) such liability has been extended to include fatalities among individuals who are not their employees.

In principle there shouldn't be any need for aggressive enforcement. Indeed, if the moral argument alone is insufficient to persuade then the loss of $127bn/ year should be enough to make the cost conscious employer realize that money is being spent needlessly on remedying the effects of poor safety management, (Kedjidjian 1999).

## Factors Causing Accidents and Compliance Failures

Time spent repairing the damage of major compliance failures is time away from managing safety effectively. It is also time (and money) that should not have had to be spent. If safety is not being properly managed more failures occur, and failures are the responsibility of the company. The corollary of this is that compliance and compliance management are corporate functions (McAleenan & McAleenan (c) 1998). Proper resource management coupled with judicious short-term investments will net long term benefits and able employers to meet their safety obligations. There a several factors accounting for the accidents and compliance failures that occur across all industry sectors including;

a. Deliberate violations. It is estimated that OSHA's existing resources for compliance inspections would only result in inspections (other than those arising from accidents) for companies once every 66 years (Karr (a) 1999). This is not sufficient to act as a deterrent, and some employers could be tempted to play the odds, opting to do less than what is required by law, relying on the luck factor to enable them to get away with it. Associated with this is the avoidance of safety procedures by companies in the pursuit of increased productivity or the retention of market positions.

b. Contracting out hazardous work with the intention of keeping the OSHA-injury recordable safety numbers down (Tyson, Nov.1999). In many areas contract work showed higher accident rates than among workers directly employed by host companies. Sixty percent of the victims of accidents in the mining industry were contract workers, although only 20% of the work force were contract workers (Willen 1998, 1999). In the chemical industry, where contract workers receive less training, the accident rate is at 2.0 compared to 0.38 for payroll workers, despite improvements in the 1990s.

c. Lack of competence of work force. This is particularly so in small businesses that have a greater number of fatalities and higher accident rates than large companies.

d. Employee behavior resulting from nil or inadequate training and supervision (Atkinson 1999)

e. Enforcement or standards shadowing. New standards have greater attention paid to them both by the enforcement agencies and employers. It is not surprising therefore to find that what once was applied with diligence is forgotten about as employers, safety officers and inspectors turn their attention to the new standard. An example of this is that lock-out/tag-out procedure which appears to get more attention than the permit-space procedures, (McGarry 1998).

f. The variation in standards across states. In addition to federal OSHA, which is responsible for the production and the enforcement of safety standards, there are also 25 states that have their own OSHA. This means that the procedures required for compliance with safety regulations vary from state to state.

g. Cost of training. McGarry (1998) reported that confined space training can cost the small businesses between $2-3,000. Coupled with the costs of training in other areas, this is seen by many business as prohibitive, forcing employers to make choices in what they can get away with, or towards purchasing/providing low quality cheap programs.

h. Quality failure, including employee complacency and the development of poor habits (Atkinson 1999).

i. A point that must be remembered is that 60% of those who die or are injured in confined space incidents are untrained or insufficiently trained personnel. In particular unauthorized rescues in confined spaces are generally carried out by untrained work colleagues, the result being that on average greater than 50% of those who die in confined spaces are such well intentioned rescuers[6]. It is incumbent upon employers to ensure that the training of personnel includes training to suppress the natural instinct to rush to assist a person in need.

## The Training Requirement

A core element in safety is that the work force is competent to do what it is required. It is a fundamental duty imposed upon an employer that he shall;

"furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees" (OSH Act 1970).

Workers who are not competent to carry out work for which they are employed are a hazard to themselves and to others, it is axiomatic that they should not therefore be engaged in any work activity in which they are not competent[7]. The responsibility for this is a corporate one that lies ultimately with the employer who must have in place procedures for recruiting a competent work force, or ensuring that the work force becomes and remains competent.

Contiguous with this concept is that when work is contracted out, the contractor or subcontractor engaged by the host company should be competent in all areas that they are required to undertake as part of their contract. And in this respect, the employees of the contractor/sub-contractor should be competent in the job and the safety requirements of the job. Host companies should make the competence requirements known to the contractor, and assess the capacity of the contractor to meet those requirements. If appropriate, specific training for the job may be provided by either the contractor or the host.

Though a host company may not have control over the competency of the contractor, it does have control over the quality of contractor it engages, and the information is provides to the contractor. For example CFR1910.119 (Process Safety Management) requires host companies to ensure the employees of contractor companies are properly trained and in regard to the Powered Industrial Truck training requirement there is an implied obligation for the shipper/consignee to assist motor carriers in the training of their drivers, by providing site-specific information to the carrier (Flatlow, 1999).

## Competence and supervision

A further consideration relates to the degree of supervision of confined space workers. This should be in direct proportion to their level of competence, and it is therefore vital to have a system to determine, at the outset and at regular intervals, that the worker is both able and competent. Competence is not determined simply by attending a training course, rather it something that builds over time and needs to be assessed after training and at regular intervals beyond. It is also about knowing personal limits so that, should the exceptional arise, the worker knows what he can deal with as result of his own experience or expertise and when to call for additional assistance.

Managers need also to be aware that an individual's level of competence can be affected by their medical and physical fitness, which can vary in between medical examinations. Any deterioration could adversely affect the safety of the workers and his colleagues while in the confined space.

The need to regularly check competence in the use of RPE, safe entry techniques and emergency evacuation arrangements is essential since there are people who only occasionally effect a confined space entry. When the time comes they need to be able to do so confident in the knowledge that they can deal with any foreseeable event. The manager can ensure his own familiarity with the procedures through direct involvement with routine competency checks (McAleenan & McAleenan 1999).

## Regulations

Reinforcing the duty to provide hazard free environments are training regulations imbedded in the OSHA standards, covering the full gamut of work activities. Examples of training standards are to be found in:

- CFR1910.1025 - Toxic and Hazardous Substances,
- CFR1910.119 - Process Safety Management,
- CFR1910.120 - Hazardous Waste,
- CFR1910.332 - Electrical,
- CFR1910.146 - Permit Required Confined Spaces, and
- CFR1910.134 - Respiratory Protection

The high-risk environment safety training industry is bolstered by the fact the OSHA has published these standards to govern safe working in high-risk environments. Companies that have permit-required confined spaces are required by law to put specific safety procedures in place including safety training (at least once for general confined space awareness, (more often as work tasks change), and annually for RPE training).

OSHA recognize the impracticability of recruiting a fully competent work force from the outset, or to expect that workers remain competent without an ongoing input to meet changing needs, technologies and work processes. The requirements, particularly in respect of high-risk environments, stipulate not just training but frequent and sufficient refresher programs to maintain the level of competence. Even from the simple aspect of a non-changing technology or process, undesirable habits develop through familiarity, complacency or a number of other human factors. As competency drops, hazards increase. Refresher training programs are designed to address these factors.

The concept that the training obligation can be met simply by sending employees onto programs, or by giving tool box talks on the relevant subject is negated by the fact that the standards require employers to ensure that the training is effective (CFR1910.1025, and 1910.134). The standards also require that the employee understands and adheres to current operating processes (CFR1910.119). In respect of permit-required confined spaces, such training must ensure that the employees "acquire the understanding, knowledge, and skills necessary for the safe performance of their duties..." and that this training is certified by the employer as having been accomplished.

The net effect of these standards is to ensure that safety training is competence based, is certified and maintains competence within the work force.

Whatever the actual practice across industry, gone are the days when mere attendance on a training program can be regarded as sufficient to meet a training requirement.

## Quality Training

Money spent on quality is not money wasted. It is widely acknowledged, in the quality field, that every $1 spent on quality improvement can net up to $7 in saving. Apply this to the safety business on the macro level then statutory spending on improving safety would significantly reduce the cost burden on the economy. Davies and Teasdale (1994) argue that it would take an investment of £2.3bn in the UK to eliminate the £16bn cost of accidents. In the US this would equate to a $18bn investment to eliminate the $127bn cost of accidents.

For employers who have provided training and find that such training is insufficient or inadequate, the question is one of value for money. Does quality cost? Have these employers bought into poor quality training programs in the mistaken belief that better programs would cost too much more? At the level of the individual employer, where money is being invested in training the concern should be that what the investment buys is adequate and sufficient to meet the requirements for safety. In the authors' experience, and the experience of many employers, dollar for dollar, the quality of training obtained varies from the poor (trainer provides handouts, short talk and signs off attendees as present) to excellent, (trainer provides tailored program, assesses and certifies outcomes of training).

The quality of training is not always measured by cost. Poor training can be costly to obtain (and costly to live with if accidents result) just as much as excellent training can be provided at a reasonable cost. There is no logical reason why high quality training should cost significantly more than poor training, and indeed there is a rationale that states all training should be of a standard sufficient to meet the requirements of safety and the law. That being the case, the opportunity for poor quality training programs would be reduced. Anything less serves only to increase the hazards in the work environment and therefore should be considered illegal. Thus we are back to the OSH Act (1970) that requires employers to ensure that employees are not exposed to recognized hazards and by implication that requires them to ensure that trainers are competent and that their programs meet the requirements laid down by the relevant OSHA standards. In this regard;

a. all training programs should be tailored to meet the requirements of the work process and the standards laid down by law,
b. participants should be fit and ready to undertake the program,
c. training should be delivered in a manner that ensures that the participants acquire the skills determined by the program objectives,
d. participants should be appropriately assessed at the end of the program and provided with competence or knowledge certificates indicating the level obtained, and finally
e. there should be a means in place where the employer can ensure, post-training, that the employees' competence and/or knowledge levels are maintained.

This is not an unreasonable requirement to put to a training provider, whether internal or external, and given that on average training costs $2-300 per day per employee (McGarry 1998), it should be considered an essential quality requirement. Ultimately, it is the employer who has to stand over the quality of training that he has purchased. As with engaging contractors, while it may be argued in court that the employer had no control over the competence of the trainer and the program, he cannot argue that he had no control over the decision to purchase a particular training program. It was this principle that determined the structure and content of Ireland's first competence-based licensing and certification program for confined spaces workers.

## Training Provision in Northern Ireland Prior to1996

Until 1996 there wasn't any independent confined space training available in Northern Ireland (NI). Confined space training was carried out by the major statutory agencies for their own employees, with little surplus capacity available to provide training for small private companies engaged in confined space work activities. The exception to this rule is the Water Service (a NI government department) that provides training to external contractors who work directly under their daily guidance (i.e. they treat them equal to their own employees). NI private companies had to travel to Scotland or England, at significant costs, to get their confined space training. This scenario provided the opportunity to provide quality affordable confined space training locally.

Setting up as an independent training company, dealing with high risk environments such as confined spaces brings a lot of concerns and responsibilities. The output from attending much of the training provided up until the mid-1990s was a certificate of attendance. All this told an employer was that his employee sat through a training course. It didn't indicate how much knowledge had been imparted or how the skills had been developed. Such a situation is not acceptable in an age or in a work environment where the competency of the workers is a critical factor in the control of risk.

## Development of the Licensing and Certification Program (LCP)

The confined space legislation in 1996 consisted of a single regulation in the Factories Act (NI) 1965. There was limited industry guidance on safe working in confined spaces. The best model for confined space safety that existed at the time was the US NIOSH standards and CFR1910.146. UK and NI have since introduced Confined Spaces Regulations with similar requirements. In setting out to develop the licensing and certification program (LCP) for confined spaces and respiratory protective equipment (RPE) the authors considered the following to be essential criteria;

a. the need for a best practice model for safety in confined spaces,
b. training would only be provided by competent safety professionals with confined spaces expertise,
c. training would take place in safe environments, simulating the hazards, as necessary,
d. candidates attending training courses would need to be medically and physically fit to undertake the training,
e. candidates attending training courses in high risk activities would be required to take knowledge tests and practical assessments before completing the course, and
f. frequent post-course refresher training would be a requirement for all candidates in order to maintain and continually improve their competence.

These requirements sub-divide into three crucial sectors; the training environment, the candidate's suitability and the development of competency-based assessments. Interestingly this strict regime for ensuring competence of both trainer and candidate was also welcomed by the insurers when offering to cover the professional indemnity risk.

## The LCP Training Environment

The training developed to satisfy the above criteria was based on international best practice. The content of the programs met legal and professional standards, all trainers on the program were competent in the confined spaces field and most of the training took place in risk free environments; i.e. classrooms and low risk training confined spaces. Where actual confined spaces were used for training, all the necessary procedures and safeguards were put in place to ensure that no immediately dangerous to life or health (IDLH) atmosphere or other hazards were present. In the normal course of events these precautions would be sufficient to ensure that the training provided would be safe and free from hazards. The variable that gave rise to the continued concern was the candidates. The safety of candidates could be assured during the training program but they would be vulnerable after training, when they returned to their workplaces, if further controls were not included in the LCP program.

## The LCP Candidate's Suitability

It was already essential to the selection process that candidates should be medically and physically fit to undertake the confined spaces and RPE program. Employers were required to have candidates certified medically and physically fit by a competent person. The LCP quality manual provided the forms the employer needed to complete.

All candidates enter the program at the lowest level unless prior knowledge, skills, attitude and awareness can be demonstrated to the satisfaction of the trainer/ assessor.

## The LCP Competency-based Assessments

The strategic question in relation to the development of an LCP program centers on how the training outcomes would be verified against the objectives set by the program. In other words, would the candidates gain new knowledge and skills and how could this be determined? In order to achieve this a core assessment procedure was devised that every candidate would have to participate in before completion of the program. This consisted of two core elements that the candidate had to satisfy;

a. a short written paper testing the level of awareness of confined space hazards and safety, and
b. a practical demonstration of the checking and use procedures for the company's own RPE.

Given the high-risk nature of the work activity a high pass mark was set. Candidates are required to score at least 80% on the written paper before they are awarded the certificate of awareness. A 100% score is required on the RPE practical assessment, fundamentally because any failure in the checking procedure or in the use of the RPE, no matter how small, could have fatal consequences in a real situation. Where confined space entry is an element of the program, a similar 100% score is required.

These procedures confirm to employers that their employees not only had attended the program, but had achieved particular levels of competence at the end of the program. Certification was only awarded to those who achieved the appropriate scores in assessment. In view of the high level or risk associated with using RPE the successful candidate was issued with a license to use RPE. There is no legal requirement that the assessment system established for the LCP program is the criteria by which employers should judge the competence of their employees, but it is a fair, reliable and valid procedure.

## The LCP Post-course Refresher Training

It is the employer's duty to ensure the continued safety of his employees after they have been trained. Therefore it is necessary, in building competence, to consider what happens needs to happen after training has been completed and what employers can do to ensure that their employees maintain and develop their competence. Often workers only enter confined spaces infrequently and even those who do enter might have little cause to use the RPE. The question then arises would employees retain the skills if they had little opportunity to apply them after the LCP training?

The solution was to build a procedure into the LCP program that required all candidates to carry out the RPE checking and donning procedure at least once a month in a real or simulated situation, supervised and signed off by a competent person within the company. This would ensure that every one who undertook the program would continue their familiarity with the practical requirements and that the equipment would be checked and used at least monthly. This was made a condition to affirm the continuing validity of the RPE license. An employer, not satisfied with an employees safety performance, could revoke the license, preventing the employee to continue working in a high risk environment when they lacked competence.

Best practice dictates that all confined space entry workers should undertake refresher programs at regular intervals and this should not be longer than three yearly intervals. Therefore the license to use RPE is valid for three years maximum, at which time it was recommended to employers to put their employees through a full refresher training program. Where national statutory requirements demand something more the program can be adapted to suit, for example, CFR1910.134 has a requirement for an annual RPE refresher the license has the facility for a third party to assess the candidate and sign the back of their license.

## The LCP NI Experience

The LCP program has been delivered to companies throughout NI since 1996 and is used in such major industries as construction, chemical, power, food processing and the utilities. Client's feedback indicates that the choice of using the LCP program was justified on a number of grounds;

a. Employers have been assured by the nature of the assessment that their employees are competent to do the work required of them in a safe manner.
b. Licensing successful candidates and committing them to a regular in-house exercise satisfied the employers need to ensure that employees remain competent.
c. The medical and physical fitness requirement adds to the employers confidence in the safety of their employees. The requirement that employees notify their employer of any medical or physical conditions that arise following training which may adversely effect their performance is also reassuring.

d. Some employers have noted that such training and certification has a positive effect when they submit tenders to government bodies for contract work.
e. Others have stated that the delivery of a program customized to their needs ensures the correct type and level of training is provided. the requirement of the program that candidates are trained on their employers equipment reassures that when the need arises they are using familiar equipment.
f. In some cases the provision of training and assessment by an external agency is regarded as more likely to be accepted and respected by the candidates than internal provision.
g. Training of this nature satisfied their legal requirement to ensure that workers assigned to any confined space task are competent.

Contracts managers in Government departments stated their key requirements in relation to the competence of contractors. They seek evidence that the contractor's safety advisor is competent and they also seek evidence that the contractors' employees have been appropriately trained.

## The LCP Sound Reasons to Proceed in US

The LCP program assures safety in all the core areas of the training program and contains a system for the employer to ensure that his employees retain and build on their level of competence. Companies using the LCP program are adopting the standards set and incorporating them into their safe systems of work. There is a sound moral base for developing competence based training and assessment programs in the field of safety generally and confined space safety in particular. Safety failures in confined spaces have a 1 in 10 fatality consequence with a greater than 50% chance that such incidents involve multiple fatalities. Statistical evidence indicates that 60% of those killed and injured in confined spaces are either untrained or poorly trained.

Where training, or lack of it is a key element in the causes of death and injury the problem must be resolved by providing it where it is absent, or redefining the standard of training where poor training has been a factor. The standard of training must be based on what knowledge, skills and competences are required to ensure the safety of employees. The requirements for confined space entry are well defined. It stems from this that a program of training must deliver on those requirements and at the end of the program be capable of making an objective determination through formal assessment on the outcomes of the training for each candidate. A statement of attendance should never be acceptable as evidence that a person has received training.

The legal argument for competence based training is in essence the moral argument enshrined in statute. OSHA standards now require that sufficient and effective training be provided. Effective training means that the training should ensure that the candidate is capable of demonstrating that he has met the objectives of the program and that he is then able to apply the training outcomes in practice. Effective training also means that it is targeted at achieving particular safety objectives. Anything less is ineffective. Therefore workers who fail to demonstrate the necessary level of competence following training are not competent for the task back in the work environment. The employer must consider what happens next.

## The LCP Quality Management System (QMS)

Following discussion with CSPs at the NSC Expo, Los Angeles 1998 and subsequent tele-conferences with ASSE in 1999 the authors were invited to develop a version of the program that would apply to confined space safety training in the US. A complete review of the LCP program and the US statutory requirements was carried out. The outcome was the development of an international LCP Quality Management System (QMS) that would facilitate the consistent delivery and independent verification of the training and assessment program.

The introduction of the quality standard is driven by the need to introduce consistency of purpose across the entire organization when it comes to producing a product or service that will satisfy the customer. The many processes involved in producing the final product need to be managed with equal vigor by skilled managers and staff in order that waste is minimized and profit is maximized. On a daily basis, all across the US, workers in high-risk environments, such as confined spaces, put their life on the line for the company. It is incumbent on employers to ensure that proper controls and systems are in place and that employees skills are developed to a level where their safety and health, and that of their co-workers, is not being compromised. Worker occupational safety and health competency is an integral part of the staff development process and should be viewed as being of positive benefit to company growth.

The QMS, developed as an ordered set of rules and methods that work together to consistently produce specific results, that is workers completing a program of training and being judged capable of entering permit-required confined spaces. The important feature being that the QMS assures consistency. Consequently the employer can have confidence that his workforce are all trained to the same standard and assessed against the same criteria.

A QMS was developed for the Licensing and Certification Program (LCP) so that other suitably qualified safety professionals could become approved assessors and run the program. The results of each LCP program are independently verified. The adherence to quality principles ensures that whether a worker has been assessed in Birmingham, England or Birmingham, Alabama he has been judged against the same standard and if successful will have demonstrated the same level of competence. This is an added benefit for US companies working in the international market.

## The LCP Standards

The LCP program is a high level, competence-based training and assessment program developed with stringent control standards that apply to the operators of the scheme, any appointed verifiers and all approved assessors (Table 3). The standards, registration system, tests and associated documentation are designed to control the quality of service. Each step in the process is verified to ensure consistency of approach and regular contact is maintained between all the key players in the scheme.

The LCP program satisfies all of the most recent requirements of the OSHA revised Confined Spaces Entry Standard 29 CFR 1910.146 which requires that;

a. employers must certify that the training required in the Standard has been accomplished.

b. certification must show the employee's name, be signed by the trainer and show the dates of the training.
c. employees and their authorized representatives are allowed to inspect certification.

Workers who successfully complete the LCP program are issued with a license to use RPE, and a certificate of confined spaces awareness. The conditions attached to the license require the holder to maintain and record their competence on a monthly basis throughout the period of validity. Failure to keep up personal competence renders the license invalid, leaving the worker and his employer exposed. It is vital therefore that companies committing to the LCP program appreciate the benefits of continually developing competence and are aware of the consequences of non-conformance. The LCP license and certificate is renewable, every three years.

Safety trainers delivering the LCP program will have satisfied the following criteria;

a. be competent confined spaces safety trainers/ consultants,
b. have a minimum of 10 years experience,
c. be medically fit to undertake RPE assessment (medical evidence required), and
d. have successfully completed the 'approved assessor' training program.

| Action | Target |
|---|---|
| **LCP Scheme Operators** | |
| 1. Allocate examination reference number | Upon receipt of request |
| 3. Issue licenses and certificates to candidates, via Assessor | Upon confirmation of results |
| 4. Remind candidates of impending expiry date of RPE License | Two months before expiry date |
| **Appointed Verifier (within region)** | |
| 1. Allocate candidate registration numbers | Upon receipt of Assessor's request |
| 4. Spot check LCP paperwork (minimum 20% sample) | Upon confirmation of results |
| 5. Update candidates results database | Upon confirmation of results |
| **Approved Assessor** | |
| 1. Maintain competence level through running of LCP programs | Minimum three per year |
| 2. Notify Verifier of LCP program | One month before start date |
| 7. Forward results to Verifier. | 10 days after LCP program |
| 9. Send licenses, certificates and covering letter to candidates, via employer | 10 days after receipt |

**Table 3 LCP Program Excerpt from Control Standards**

## The LCP Process

During the LCP program candidates are trained in and examined on their awareness of safe working and assessed on their confined spaces practical skills, following the standards set down in the LCP QMS (Appendix 1). Candidates who successfully complete their examination and practical assessment are awarded licenses to use RPE and certificates of confined spaces awareness.

A verifier will spot-check the LCP documentation before the appropriate licenses and/ or certificates are awarded to the candidates. Occasionally, as demanded by the QMS the verifier will visit an assessor to ensure that the LCP standards and candidate's documentation are being properly maintained. The verifier has the right to meet with some of the candidates to get their feedback on the LCP program.

## LCP Roles and Responsibilities

The LCP program is managed and maintained through a network of verifiers and assessors, under the control of the scheme operators. Each have specific roles and responsibilities that are detailed in the QMS. They can be summarised as follows;

1. The scheme operator is responsible for developing the LCP standards and QMS, issues any amendments and hold in archive current and previous versions of the LCP standards. Additionally they will appoint verifiers and assessors, promote the LCP in the international market and issue the licenses and certificates.
2. The verifiers are responsible for promoting the LCP, maintaining a candidates register, and monitoring the activities of assessors within their allocated region. Their most important function is to verify that standards are consistently maintained and that assessments are fair, reliable and valid. Appointed for their technical competence the verifier will be in a position to act on behalf of the scheme operator in the arbitration of any disputed decisions. They will be in the best position to judge the eligibility of extending assessors approvals.
3. Approved assessors must maintain their technical and assessor competence throughout the period of approval, run the scheme with integrity and respect the confidences gained through their involvement in the LCP program.

## LCP Resources

The LCP program has an extensive range of resources that are available for use by approved assessors and candidates. The scheme operators are working to continually improve the quality and extent of information available, through use of the internet and the development of computer-based simulators.

## LCP – The Future

The LCP and the associated QMS was initially developed to cope with the competency demands of working in confined spaces. The model has a much wider application and would lend itself to diversification into other high-risk working practices.

The LCP program has run for over four years in Ireland and many candidates are now on their second set of licenses and certificates. The value of the scheme is accepted by those companies that have used it and returned to it when licenses have expired. The scheme owners believe that the future of the scheme is recognition by or transfer of ownership to the professional safety bodies. The case for recognition of this scheme has been made to ASSE and the UK's Institution of Occupational Safety and Health. As reported elsewhere in this paper the Irish statutory training agency (FAS) is considering piloting a similar scheme.

## Appendix 1 The LCP Program (US Version)

The LCP training program incorporates the following six elements;

1. **Law in respect of confined spaces** - covers general duties of employee and employer in respect of occupational safety and health and the specific requirements of 29 CFR 1910.146.
2. **Hazards in confined spaces** - explores the general hazards associated with confined spaces and challenges candidates to consider the confined spaces hazards within their own industry.
3. **Risk assessment, analysis and controls** - introduces procedures for carrying out risk assessments and determine the measures to control the level of risk associated with confined space entry.
4. **Permits** - covers the 'permit-required' confined spaces aspect of 29 CFR 1910.146 and the rationale behind the various elements on the permit. It also includes authorized personnel responsibilities, lock out/ tag out and how to complete and how to use a permit.
5. **Emergency procedures** - Though emphasized throughout the program, this element focuses specifically on how emergencies arise, what happens during an emergency and what personnel are expected to do to assist the rescue team/ rescue services.
6. **Equipment** - introduces the candidates to confined space entry equipment, particularly the RPE sets to be used by workers. Using practical demonstrations, candidates will be taught how to examine and check the condition of their RPE sets, how to don the RPE, how to obtain a face seal and safely use the equipment, especially when an emergency alarm is sounded. (This element does not replace the employer's requirement for fit testing under CFR 1910:134).

The assessment is in two parts, covering all six sections of the training program.

Part 1. Written paper leading to 'Confined Spaces Certificate of Awareness'

A one hour short answer paper covering all the various elements of the program. This will be a combination of several multiple-choice questions and open questions, requiring no more than a short paragraph to answer. A specific examination paper is prepared for each LCP

Part 2. Practical assessment on RPE leading to a 'License to use specific RPE'

Candidates are required to demonstrate their ability to carry out pre-use checks and tests on their RPE, don the RPE, obtain a face seal and safely remove the equipment. They will also be expected to don escape RPE set in a simulated emergency. At the discretion of the assessor, oral questioning will take place to supplement the written element

Part 3. Optional confined spaces entry leading to a 'Certificate of Confined Spaces Entry'

Candidates that have successfully completed parts 1 & 2 may undertake this assessment. This assessment requires candidates to effect a permit-required confined spaces entry as part of a team (2 person minimum) following an accepted safe system of working in accordance with CFR1910.146. The assessment will be stopped if the Assessor observes any unsafe acts or conditions.

## Notes

[1] Defined as injuries leading to at least one additional day absent from work.
[2] Hoskin's figures are taken from Bureau of Labor Statistics, Census of Fatal Occupational Injuries.
[3] This is illustrative of lock-out/tag-out failures. The European Union position in respect of confined space safety and permits incorporates lock-out/tag-out (isolation) procedures. EEI therefore includes lock-out/tag-out in its confined spaces safety programs.
[4] Defined as wage and productivity losses, medical expenses, administration expenses, employers costs in accident investigation, reporting requirements etc., (Hoskins 1998, 1999).
[5] In 1998 only 30 countries had a GDP greater than $130bn.
[6] Human nature being what it is there will always be the 'have a go' hero who if successful will be praised for their bravery and if unsuccessful becomes another fatality statistic.
[7] In 1999 $1.1m in penalties were imposed on two Houston based companies cited for willful violations including the use of untrained workers to remove potentially dangerous asbestos.

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**Dynamic Safety Management in the Construction Industry**
*Operational Analysis & Control Model*
**ISSA Paris 2001**

## Introduction

Construction workers in the UK are five times more likely to be killed and twice as likely to sustain a major injury or ill health than their counterparts in other industries (NCE, January 2001). In the 1999/ 2000 period there were 86 UK construction industry fatalities and in excess of 5000 non-fatal major accidents.

In a call for a UK national construction health scheme UCATT the UK's construction workers union recently reported;

- New cases of assessed disablement are highest in construction for asbestosis and mesothelioma - between five and six times the average for all industries,
- Rates for vibration white finger, dermatitis and hearing loss are relatively high,
- More than 1.2 million working days were lost in the construction industry during 1995/6, as a result of work-related ill-health and over 0.6 million as a result of work-related injury, totalling almost 1.9 million days
- Around 7.5% of all those currently or recently working in construction reported suffering from an illness caused by their work

In the US the National Institution for Occupational Safety and Health (NIOSH) refers to accidents as 'preventable injuries', a useful definition to bear in mind when considering dynamic safety management in the construction. The question for our industry is; why do we accept all these deaths, injuries and incidents of ill health? We have the technological and intellectual capability to prevent accidents.

The basic premise in European construction safety legislation is that construction projects should designed, built, maintained and demolished in a manner that does not cause harm to the workers or others who come in contact with them. We do not need additional laws to control the construction industry, rather we need to work with what we have and manage it better. This short paper examines how a dynamic management model, focussed on elimination of or control of hazards rather than risks, can yield significant results.

Good management is concerned with controlling operations/processes/systems so as to achieve the objectives of the operation etc. The degree to which it achieves this is the degree of effectiveness of management. Management must be focussed on the outcomes, rather than simply the process and methodologies if it is to achieve and maintain its effectiveness. It must recognise and respond appropriately to factors that impinge upon the outcomes and ensure that the desired outcomes are maintained. Thus effective management is dynamic management.

The efficacy of management is in no way accidental. It requires thought and planning from the outset. Having established the outcomes of an operation, how they are to be arrived at and the necessary steps to successful achievement must be considered. Additionally the project management team have to keep the potential barriers and the influence of internal and external changes in the market, technology etc. under constant review. If required, the team has to be willing and ready to alter their activities, change or drop their planned outcome to meet the new challenges.

Management that focuses on the procedure or the process, on doing things "the right way", neglects to pick up on the failures in the systems since whenever outcomes fall or go other than as planned the assumption is that the problem rests elsewhere since things are being done "right". This is rigid management or non-effectiveness in principal (even if on occasions it achieves the outcomes set). Effective management is about doing the "right things" (not just about doing things right).

This principal, of an effective management being concerned with outcomes, falls short if the outcomes are defined purely in terms of product. Outcomes must be defined in the wider quality assurance terms that include quality, quantity, cost effectiveness of production, safety of operators, safety of customers, environmental issues, profitability etc. In other words, the right outcomes must also be established.

The conditions therefore are, the right outcomes plus the right activities to achieve success.

The rights activities are those that control the operation. Where risk exists, control is lost because risk means that there is a possibility that harm may result, and this implies that the operation is not fully controlled. The problem with risk, no matter how remote the probability, is that the possibility of an uncontrolled event occurring could be the next time (and it always could be the next time). There is nothing in the theory that states that a 1:1,000,000 event could not occur on 2 (or more) consecutive occasions.

Every action will have an outcome that is either desired or undesired. In effect every action has only one desired outcome but a multitude (theoretically infinite) of undesired outcomes.

Absolute control = absolute certainty of outcome.

Planning any construction project without reference to the safety requirements means that the project will fail, certainly and spectacularly. Effective management requires that safety is considered as an integral aspect of the project, not an after thought nor a discrete element, but central to and fully integrated with the project objectives. What planning does is consider the objectives, the mean and the methods of achieving them. By definition planning leaves nothing to chance. All elements of the projects and every eventuality are considered, in advance and appropriate steps, actions developed and scheduled. Anything that is left out, by accident or design, exposes the project to risk and consequently the likelihood of an undesirable outcome.

In defining the outcomes, and all the relevant considerations, the model requires the identification of the principal actors necessary for the establishment, development and successful achievements of the project. The competence and expertise of a wide range of personnel are needed to input to the various aspects of the project, to establish the parameters of what is achievable within the constraints of;

- finance,
- engineering & technical capabilities,
- environmental management, and
- human interaction,

during and after the project. There will be contradictions between the demands of the various elements that will require expertise to not only resolve them effectively, but to identify and define them in the first instance. The occupational safety and health (OSH) input will not solely be derived from OSH professionals, but must also come from experienced and competent managers and supervisors, engineers, specialist experts and of course the workers own representatives.

Effective management and the Operational Analysis and Control (OAC) model advocates that those who are involved in the project at whatever stage, will have a contribution to make to the elimination/ control of hazards (i.e. those factors that will negatively impact upon any element of the project, not just the safety).

The OAC model does not advocate the minimisation of risk, as this perception of safety accepts the possibility of accidents and hopes (with fingers crossed) that they will be of sufficient low probability that they will not occur. 1,220 deaths and 470,000 disabling injuries annually, as a result of construction industry accidents [preventable injuries] costing the USA economy $billions crossing fingers is definitely the wrong route for management. The correct option is to go for elimination of hazards, or hazard control if elimination is not possible, so that the accidents probabilities are removed not minimised. The OAC model is designed to achieve this.

## Operational Analysis and Control Model

The OAC model was introduced to an N. Ireland Government department in 1998 and in the intervening '3 year period' accident rates were reduced by 49%. Further improvements are anticipated as the managers become more familiar with the concept and become more competent in the process.

The purpose behind the operational analysis and control model is to ensure that work operations are carried out in strict accordance with all relevant 'safe working' procedures. In this way we can make sure that people, plant and property is protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced.

Assessment is only one aspect of operational management and when viewed in isolation often fails to achieve the desired effect; namely the safe completion of the work operation or activity. The operational analysis and control model is the way forward. In this model you will integrate all aspects of your work operation including occupational health. This emerging model is in three stages as follows;

### A. Stage 1 – Analyse the Operation

1. What can cause harm? (Look for the harm factors in the work operation itself, the workers, the materials, the machinery and plant, the public & visitors and the environment).

2. What are you doing about it? (Once you know what can cause harm you look for the controls that are needed to prevent that harm from occurring).

3. Is it enough? (At this stage, before embarking on the work operation, consider whether you have done enough to prevent harm. If necessary seek specialist advice e.g. from trade or professional associations, manufacturers, your National Statutory Safety Body, other safety professionals etc). Things can go wrong and it important to try and anticipate that as early as possible. Ask;

- What could go wrong?
- How could it happen? and

- How would you deal with it?

Asking the questions at the outset focuses the mind and ensures that you have considered all the foreseeable incidents and planned for them. Additionally you are prompted to consider what emergency plans you need to have in place prior to starting an operation.

B. **Stage 2 – Manage the Operation**

1. What has to be done? (Having carried out the analysis you must list what has to be done to ensure a safe outcome to the work operation. E.g. have you made your employees aware of what can cause them harm and what they must do? do you know what training they need?, are there written safety instructions? Does everyone know who is responsible and for what? etc).

2. What resources do you need? (Material, human, financial). It is important that, having identified the resources, you make them available. (Some will be needed well in advance of any work operation. Build your controls into your budget and business plan).

3. When does the operation need to be reviewed? Believing that you have a safe workplace is a sure way of ensuring that you have not. Like every aspect of your work safety needs to be continually managed and improved, as necessary. It is important therefore that a time or circumstance is set for reviewing the effectiveness of the management controls. The review period could be;

- When new processes or new equipment is introduced to the operation,
- When new techniques have been developed,
- When statutory obligations require it,
- When resources inputs are set to change,
- When an accident or incident occurs, or
- At regular intervals (determined by the nature and complexity of the hazards present).

**Note**: The list above is not exhaustive. Carry out an effective review at any other time, should you feel it is warranted.

C. **Review the Effectiveness of the Operation**

1. Has the operation progressed as planned? Things change or things can go wrong. You need to be aware of the effects of any change and try to anticipate how they will need to be dealt with. Ask yourself the following questions;

- What has changed since the last operational analysis?', 'What effect will it have on operational management?', and 'How will it be dealt with?',

  If nothing has changed then note that the review has taken place and set the next review date.

Where things have gone wrong ask the following;

- 'What went wrong?', 'How did it happen?', and 'How did you deal with it?'.

 

**Note**: We do not always get it right but if an accident does occur that is no reason to give up or to accept lower standards. Accepting accidents as inevitable is fatalistic. The objective of integrating the highest standards of health and safety with improved business performance means that the end product/ service must be achieved in a manner that protects employees and the public from harm. Operating to any less a standard will only guarantee a negative outcome and ensure that accidents continue.

2. Detail the changes needed. If changes have occurred then itemise them and consider how they will affect the operation.

3. List the improvement actions. Draw up an action plan, identifying the resources implications, managers responsible for completing the actions and the timescales for completion.

**Way forward**

"If you can't afford the safety control measures then you can't afford to do the job".

This basic thought cuts across all levels and all industries. In product manufacture the total cost needs to include the safety costs and in turn this will influence the market price. This is what is demanded in the European essential safety requirement[1]. When a construction client is buying work they need to insist that contractors include safety measures in their methods of working however their estimate for the work must allow the contractor to put safety measures in place. The client allowing for adequate resources needs to include a realistic timescale for the completion of the work as well as suitable recompense.

The partnership approach where client, designer and contractor are all working towards an agreed end is the way forward. In Ireland construction employers/ industry federations, major client bodies, statutory agencies and professional institutions came together recently to introduce 'Safe T Cert.' to the construction industry. In it's infancy this scheme brings a management system and audit protocol to the contracting firms. Audited annually and independently verified, the process is designed to record a level of safety and monitor continual improvement. As this program rolls out it should raise the awareness of and competence in safety management across the construction industry and since it is based on international best practice there is no reason why it should not work in other countries across the globe.

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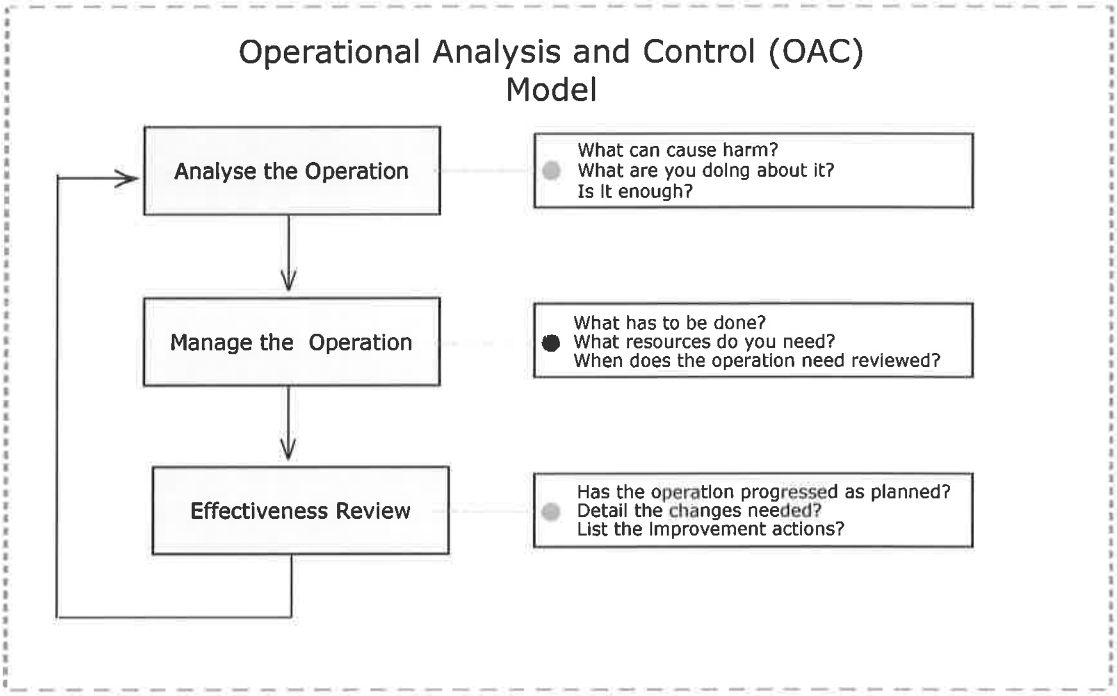
[1] under normal, controlled or reasonably foreseeable conditions of use the products do not present a risk of death or personal injury to anyone keeping, using, assembling or dismantling them.

# A Different Approach – Operational Analysis and Control

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## A Different Approach – Operational Analysis and Control


### Abstract

Risk Management has failed to achieve an acceptable level of workplace safety and it is time to rethink the strategy. It has failed because the management of risk implies that there is a degree of acceptable risk, consequently for management the task is fundamentally to determine what that degree is and to ensure that activities can be undertaken within acceptable parameters. In this regard risk management is, at best, an inexact science based on the premise that it is neither practicable nor feasible to have knowledge of the particulars of a process to control the outcomes sufficiently. Alternatively it is viewed as the product of a misconception about the inevitability of unplanned and uncontrolled incidents.

Workplaces are hazardous environments. Some hazards can be eliminated or contained through good engineering design solutions and others, inherent in the process, have to be worked around. The Risk Management model starts off it's analysis by looking at the hazards, trying to determine the likelihood of the hazards being realized [accidents], and quickly loses sight of what is important because the focus is too narrow. Whereas the Operational Analysis and Control model does not start with the identification of the hazard, rather it goes to the real starting point; the work operation, and determines from the outset what is needed to achieve a safe outcome. The safety professional and the business manager's objective must be 'a safe outcome to a successful work operation' and in that there is a need to start to look at anything that will thwart the achievement of that aim.

Some safety practitioners argue that, "there are always going to be injuries and deaths in the workplace". However accepting this fatalistic approach to safety as an inevitable outcome sets the expectations and limitations. It is only possible to get closer to an acceptable standard of safety if it is defined at the outset and the operation is properly managed to allow it to be achieved. There can only ever be one standard, no matter how you dress it up, namely that the product or service is produced in a manner that will not injure workers or others who come into contact with it. That straightforward position, extended, includes no damage to the environment or to profitability. In other words it is not unreasonable to consider all the potential losses and put the proper controls in place prior to commencement. Proper management of the entire operation requires that you define your operational outcome, provide the resources and review to consider the possibility of failure, prior to commencement, during the process and at various other stages. Operating to any less a standard will only guarantee a negative outcome and ensure that accidents continue.

If the safety, not the risk, is managed and we can control the safety of the operation then it does not matter how hazardous the environment is since the operation itself is non-hazardous and the outcome will always be non-injurious.

This paper challenges the concept of risk management itself and argues that although techniques may improve, risk management inevitably relies on subjective judgments that cost the United States billions of dollars annually, as a direct result of safety, health & environmental failures. This paper argues for a paradigm that shifts the onus from managing risk to managing the operation. It presents a model of operational management where control of the operation flows from the essential foundations of knowledge and understanding of each of the integral elements of the overall operation.

The paper also examines the relationship between the core participants in the production process, worker, contractor, client and legislature, and argues that effective operational management necessarily requires each to adopt a perspective that acknowledges and acts upon the duties and obligations each owes to the others. These obligations extend to their need to be fully cognizant of the operation and competent in the exercise of their particular role.

## Introduction

In the UK construction workers are five times more likely to be killed and twice as likely to sustain a major injury or ill health than their counterparts in other industries.[1] In the 1999/ 2000 period there were 86 UK construction industry fatalities and in excess of 5000 non-fatal major accidents.

In south Florida, in a typical year in the late 1990s, as many as 70 construction workers a year died on the job.[2] Although this figure is decreasing OSHA's area director, Luis Santiago, acknowledges that, "South Florida remains amongst the nations most dangerous places to work in construction". (Ibid.)

In Northern Ireland (NI) the construction industry fatality rate per 100,000 workers is 13.2, in the UK it is 5.3 and in the US the 'three year' average rate for fatalities is 14.2. The all industry figures for NI are 1.95 and 0.7 for the UK.

Worldwide, the 'all industry' figures for workplace accidents and fatalities do not make good reading.

- Between 1996 and 1998 there were 15,250 unintended work-related fatalities in the USA,
- Between 1998 & 1999 there were 7.7 million disabling injuries, [3]
- In the UK, new cases of assessed disablement are highest in construction for asbestosis and mesothelioma – (between five and six times the average for all industries),
- More than 1.2 million working days were lost in the UK construction industry during 1995/6, as a result of work-related ill-health and over 0.6 million as a result of work-related injury, totalling almost 1.9 million days
- In the USA, half of the 8.5 million work place accidents in 1997 resulted in 185 million lost days,
- In 1998 the cost to the US economy as a result of accidents at work was $127bn.,[4] the UK economy, £20bn., and Australia, A$27bn.

Although the $127bn cost of accidents in the USA represents only 1.8% of the country's GDP it is the equivalent of:

- an annual cost to each small business of $21,167, or

[1] New Civil Engineer (Professional Engineer's magazine), January 2001
[2] Palm Beach Post, June 22nd 2002
[3] Hoskin, Alan F, Safety & Health, 1998 - 1999
[4] Karr A, Safety & Health, 1999

- the profit on over $700,000 production / sales per business (based on a 3% margin), or
- $1,082 from the wages of each employed worker.

Put into a global perspective, the major western economies are expending more per year on accidents and compliance failures than the GDP of most countries in the world.[5]

In the US, the National Institution for Occupational Safety and Health (NIOSH) refers to accidents as 'preventable injuries'[6], a useful definition to bear in mind when considering dynamic safety management. The question for industry is;

- Why do we accept all these deaths, injuries and incidents of ill health when we have the technological and intellectual capability to prevent accidents?

**Legislation – The Intent**

The core legal requirement for employers on both sides of the Atlantic is to provide work places and environments that are free from recognized hazards that cause or are likely to cause death or serious physical harm to employees. The parent law is then supplemented by regulations, approved codes of practice and guides that provide more specific details on how the fundamental duty may be met in regard to specific work operations and industries. Thus, in Europe for example, the basic premise in construction safety legislation is that projects should be designed, built, maintained and demolished in a manner that does not cause harm to the workers or others who come in contact with them. For many years now legislators have been intent upon creating the conditions whereby risk in the workplace would be eliminated. In 2000, the UK's Health & Safety Executive [OSHA equivalent] issued a discussion document on regulating higher hazards in the workplace. Principal 2 stated,

> "Permissioning regimes require operators to describe how they plan to achieve and maintain control, and to demonstrate active commitment to the effective management of risk. The overall objective is to secure an integrated and coherent approach to *eliminating hazards* (our emphasis) and managing residual risks that would work without the intervention of the safety regulator".[7]

However despite the existence of our present laws, the introduction of new laws, and the continuing implementation of supplementary regulations and codes of practice, workplace

[5] In 1998, only 30 countries in the world had a GDP greater than $127bn., Economist.
[6] Becker P, Lecturer WVU, private conversation with author (ISSA Paris December 2001).
[7] HSE Books, DDE15

accidents continue to occur unabated, albeit with a decreasing rate of incidence, in many instances. What those who assess the situation and call for new laws and tighter controls fail to appreciate that it is not the standard of the law that causes accidents in the workplace. The state aims to eliminate workplace hazards and many safety professionals understand that intent behind risk management. Yet the mistaken notion has grown up around safety that risk management means the reduction of risk to acceptable levels. This is far from being the intent of legislation. If the fundamental legal requirement is to provide safe working environments and products, then we do not need additional laws to control industry, rather we need to reappraise, work with what we have and manage it better.

What is called for is a dynamic management model, focussed on elimination of or control of hazards rather than risks, that can yield significant results.

### Effective Management

Good management is concerned with controlling the operation/ process/ system in order to achieve its objectives. The extent to which it is achieved is directly linked to the degree of management effectiveness. Management must be focussed on the outcomes, rather than simply the process and methodologies if it is to achieve and maintain effectiveness. It must recognise and respond appropriately to factors that impinge upon the outcomes and ensure that the desired outcomes are maintained. Effective management is dynamic.

The principal that management is concerned with outcomes falls short if the outcomes are defined purely in terms of product. Outcomes must be defined in the wider quality assurance terms that include quality, quantity, cost effectiveness of production, safety of operators, safety of customers, environmental issues, profitability etc. In other words, the right outcomes must also be established. That is effective management.

The efficacy of management is in no way accidental. It requires thought and planning from the outset. Having established the outcomes of an operation, how they are to be arrived at and the necessary steps to successful achievement must be considered. Additionally the project management team have to keep the potential barriers and the influence of internal and external changes in the market, technology etc. under constant review. If required, the team has to be willing and ready to alter their activities, change or drop their planned outcome to meet new challenges.

When management focuses on the procedure or prescribed process, on doing things "the right way", the likelihood is that it will pay little or no attention to the system failures since whenever outcomes fail or go other than as planned the natural tendency is to assume that the problem rests elsewhere since things are being done "right". This is rigid management or non-effectiveness in principal, even if on occasions it achieves the set outcomes. Effective management is about doing the "right things" not just about doing things right.

The conditions therefore are, the right outcomes plus the right activities to achieve success.

**Risk Management Approach – The Negation:**

The right activities are those that control the operation properly. However, where risk exists, control is lost because risk means that there is a possibility that harm may result, and this in turn implies that the operation is not being fully controlled. In essence, there are no risks in an operation, only hazards that need to be eliminated or controlled. Risk exists only where there is ignorance of some or all of the facts, that is that you don't know whether you will succeed or fail. Every action will therefore have an outcome that is either desired or undesired. In effect every action has only one desired outcome but a multitude (theoretically infinite) of undesired outcomes. A managed operation, by contrast, is one in which all of the hazards have been considered and the controls have been put in place so that the operation itself is free from risk. Either you will achieve your objective or you won't. If risk continues to exist it can only be because there are insufficient controls and that may be for a variety of reasons. Therefore, by managing the operation, concern can then be focused on the reliability of the control mechanisms rather than the probability of exposure to the hazard itself.[8]

'Risk' is a subjective measure of the possibility of danger being realised, used where there is an absence of certainty. In any absence of certainty you only have 'chance' to rely upon and it is chance that determines which of two outcomes are likely in the workplace; incident or no incident.

Management, on the other hand, is the authoritative control of operations. Where there is control of an operation the 'chance' element is removed and the only possible outcome is that which has been established at the outset. If the outcome cannot be determined with certainty then chance exists and any action taken is a gamble that the achieved outcome will be the desired one.

[8] Gerry Ayers, Safety Professional, February 2002, private correspondence to authors.

In practice risk management posits an acceptable level of risk and proceeds to manipulate the circumstances to increase the odds in favour of a non-injurious outcome. This fact was recognised by the US armed forces when they adopted Operational Risk Management (ORM) as a decision making tool in the early 1990s,

> "ORM is ... used by people at all levels to increase operational effectiveness by anticipating hazards and reducing the potential for loss, thereby increasing the probability of a successful mission".[9]

(Note that the [ORM] procedure is not designed to eliminate loss or to guarantee success, merely to reduce loss and increase the probability of success, (though if hazard elimination is possible it is to be taken)).

The acceptable level of risk concept is reinforced by the requirement to accept the risk when the benefit is greater than the risk. By the very nature of combat, this is probably the only approach open to the decision makers, but in non-combatative situations, whether in the military, and certainly in the industrial and work environments, this approach has the potential for some very callous decision making, e.g. where it may be cheaper to compensate injured workers than incur the costs of introducing safety measures.

Ultimately, by accepting and acting on any level of risk we are gambling with the safety of workers. In a recent article in ASSE's professional journal Dominic Cooper commented; "Taking a more relaxed viewpoint has enormous practical implications. For example, in the UK, aiming for a 99.9% success rate would mean accepting that each day;

- 10 trains would crash on the rail network,
- 15 babies would be dropped on the floor at birth,
- 125 surgical operations would go wrong,
- 27 people would be wrongly prescribed dangerous drugs,
- 72,000 cheques would be deducted from the wrong bank accounts,
- 88 missed heartbeats would be experienced by each citizen,
- 96,000 items of mail would be lost by the Royal Mail, and
- Hundreds of people would be injured at work. "

Had this analysis been applied to the US the figures could be five times greater. "These statistics" Cooper continues, " support the goal of aiming for zero incidents rather than accepting 99.9%".

But not every safety professional will accept this. In a debate last year amongst members of the UK's Institution of Occupational Safety Health (IOSH) one contributor stated;

> "Risk management is about determining what risks require managing to what level. Determining the level of acceptable risk is just as important as managing the risk itself.
> Looking at larger organisations, some accept a level of fatality! The rail industry accepts 1 trackside fatality per 100,000 employees as the target. If this is achieved then everyone will be happy and give themselves a pat on the back".

The authors, however, don't see the dead employee, his family or his friends cheering. The idea of multiplying one number by another to give a risk score and thus an action priority will not wash in court when the grieving widow is sat in front of the jury.[10] In that respect how many managers would like the task of choosing and informing one of their employees that statistics demand that he is to die today?

Risk management, by definition, cannot be anything but self-contradictory and as practised accepts that an injurious outcome to some work activities is unavoidable such that it merely seeks to reduce the likelihood. Accepting this as an inevitable outcome sets expectations and limitations. Risk management supports a fatalistic approach to safety and seeks to limit the likelihood of injury rather than to eliminate it totally. Another contributor to the IOSH debate made a statement about accepting the application of the "reasonably practicable risk/ sacrifice equation", i.e. an equation whereby the risk is taken if the benefits are greater than the loss, Taken together with the point regarding the rail industry figure of 1 death in 100000 employees being acceptable substantiates the position that risk management accepts failure.

What happens when the odds are remote; is the risk worth taking?

The problem with risk, no matter how remote the probability, is that the occurrence of the uncontrolled event could be the next time (and it could always be the next time). Bear in mind that a risk is basically the element of chance in an activity, whether it is 50:50 or 1:1,000,000. Every week millions of people put their money on lesser odds in their national lotteries and most weeks one or more come up "trumps". Work environments, where the element of chance is retained, for whatever reason, are environments where every week someone's number comes up. That is why risk costs the USA more than $127bn and the UK more than £20bn every year.

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[9] US Marine Corp, "Introduction to Operational Risk Management"
[10] Contribution to an IOSH debate, November 2001.

Furthermore, there is nothing in the theory that states that a 1:1,000,000 event could not occur on 2 (or more) consecutive occasions. No matter what the odds are, no matter how well "managed" the activity, the next time could be that one in a million time because there is no chance rule that says the activity has to be done a million times before the accident. In fact every time could theoretically be that one in a million time.

"Risk Management" simply tries to improve the odds. However, if safety, not the risk, is managed and we can control the safety of the operation then it does not matter how hazardous the environment is since the operation itself is non-hazardous and the outcome will always be non-injurious.

## Operational Control - Certainty of outcome

The purpose behind the Operational Analysis and Control (OAC) model (below) is to ensure that work operations are carried out in strict accordance with all relevant 'safe working' procedures. In this way we can make sure that people, plant and property are protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced.

Planning any project without reference to the safety requirements means that the project will fail, certainly and spectacularly. Effective management requires that safety is considered as an integral aspect of the project, not an after thought nor a discrete element, but central to and fully integrated with the project objectives. What planning does is consider the objectives, the means and the methods of achieving them. By definition planning leaves nothing to chance. All elements of the projects and every eventuality are considered, in advance and appropriate steps, actions developed and scheduled. Anything that is left out, by accident or by design exposes the project and the company to risk and consequently the likelihood of an undesirable outcome.

Absolute control = absolute certainty of outcome

In defining the outcomes, and all the relevant considerations, the Operational Analysis and Control model requires the identification of the principal actors necessary for the establishment, development and successful achievements of the project. The competence and expertise of a wide range of personnel are needed to input to the various aspects of the project, to establish the parameters of what is achievable within the constraints of;

- finance,
- engineering & technical capabilities,
- environmental management, and
- human interaction,

during and after the project. There will be contradictions between the demands of the various elements that will require expertise to not only resolve them effectively, but to identify and define them in the first instance. The occupational safety and health (OSH) input will not solely be derived from OSH professionals, but must also come from experienced and competent managers and supervisors, engineers, specialist experts and of course the workers own representatives.

Effective management and the OAC model advocates that those who are involved in the project at whatever stage, will have a contribution to make to the elimination/ control of hazards (i.e. those factors that will negatively impact upon any element of the project, not just the safety). This applies equally where a client engages a contractor. The client needs to ensure that all relevant OSH information is made available to the contractor and that time and resources have been suitably budgeted for. Similarly for the contractor, he must demonstrate competence to carry out the work; such competence extends to have adequate funds, time and other relevant resources. The OAC process lends itself to the contract tendering process.

The OAC model does not advocate the minimisation of risk, as this perception of safety accepts the possibility of accidents and hopes, 'with fingers crossed', that the probability is so low that they will not occur. However with 1,220 deaths and 470,000 disabling injuries annually in the US construction industry costing the economy $billions crossing fingers is definitely the wrong route for management. The correct option is to go for elimination of hazards, or hazard control when elimination is not possible, so that accident probabilities are removed not minimised.

**Case Study**

The OAC model was introduced to an Northern Ireland Government department in 1998 and at the end of Year 3 of it's '3 year bedding in period' reportable accident rates had reduced by 49%, or 22% on the 3 year rolling average. The resultant reduction in the reportable accident rate was more than double the performance target set by the CEO at the time of introduction.

Further improvements are anticipated as the managers become more familiar with the concept and become more competent in the process. A target for the achievement of a further 20% reduction has been set for the year 2005.

The OAC has been audited each year since it was introduced and 85% to 95% compliance is being reached consistently.

To date the organisation has received two prestigious awards for it's safety management (one across the UK and the other across Ireland). The CEO and the management Board are delighted with the results and enthusiastic about the flexibility built into the process.

**Operational Analysis and Control Model**

The operational analysis and control model is the way forward. The model integrates all aspects of the work operation including occupational health. This emerging model is in three stages as follows;

A. **Stage 1 – Analyse the Operation**

1. What can cause harm? (Look for the harm factors in the work operation itself, the workers, the materials, the machinery and plant, the public & visitors and the environment).

2. What are you doing about it? (Once you know what can cause harm you look for the controls[11] that are needed to prevent that harm from occurring).

3. Is it enough? (At this stage, before embarking on the work operation, consider whether you have done enough to prevent harm. If necessary seek specialist advice e.g. from trade or professional associations, manufacturers, your National Statutory Safety Body [OSHA], other safety professionals etc). Things can go wrong and it important to try and anticipate that as early as possible. Ask;

- What could go wrong?
- How could it happen? and
- How would you deal with it?

Asking the questions at the outset focuses the mind and ensures that you have considered all the foreseeable incidents and planned for them. You are also being prompted to consider what emergency plans you need to have in place prior to starting an operation.

B. **Stage 2 – Manage the Operation**

1. What has to be done? (Having carried out the analysis you must list what has to be done to ensure a safe outcome to the work operation. E.g. have you made your employees aware of what can cause them harm and what they must do? do you know what training they need?, are there written safety instructions? Does

[11] For example this could be safety programs, permits, manufacturer's guidance, safety and personal protective equipment etc.

everyone know who is responsible and for what? etc).

2. What resources do you need? (Material, human, financial, timescale). It is important that, having identified the resources, you make them available. (Some will be needed well in advance of any work operation. Build your controls into your budget and your business plan).

3. When does the operation need to be reviewed? Believing that you have a safe workplace is a sure way of ensuring that you do not. Like every aspect of your work safety needs to be continually managed and improved, as necessary. It is important therefore that a time or circumstance is set for reviewing the effectiveness of the management controls. The review period could be;

- When new processes or new equipment is introduced to the operation,
- When new techniques have been developed,
- When statutory obligations require it,
- When resources inputs are set to change,
- When an accident or incident occurs, or
- At regular intervals (determined by the nature and complexity of the hazards present).

**Note**: The above list is not exhaustive. Carry out an effectiveness review at any other time, should you feel it is warranted.

C. **Review the Effectiveness of the Operation**

1. Has the operation progressed as planned? Things change or things can go wrong. You need to be aware of the effects of any change and try to anticipate how they will need to be dealt with. Ask yourself the following questions;

- What has changed since the last operational analysis?', 'What effect will it have on operational management?', and 'How will it be dealt with?',

  If nothing has changed then note that the review has taken place and set the next review date.

Where things have gone wrong ask the following;

- 'What went wrong?', 'How did it happen?', and 'How did you deal with it?'

**Note**: We do not always get it right but if an accident does occur that is no reason to give up or to accept lower standards. Accepting accidents as inevitable is fatalistic. The objective of integrating the highest standards of health and safety with improved business performance means that the end product/ service must be achieved in a manner that protects employees and the public from harm. Operating to any less a standard will only guarantee a negative outcome and ensure that accidents continue.

2. Detail the changes needed. If changes have occurred then itemise them and consider how they will affect the operation.

3. List the improvement actions. Draw up an action plan, identifying the resources implications, managers responsible for completing the actions and the timescales for completion.

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**Way forward**

Mike Gutierrez, a safety expert at Gables Residential Trust, a Boca-Raton based apartment developer, stated…"there's so much competition when you bid. A lot of companies tell us "We can't afford to work safe"".[12]

This is one by-product of viewing safety as an add-on rather than an integral element of the business, with the result that the callous decision-making that can result from the risk management approach manifests itself in safety being cut from project costings in the effort to win contracts. But as Philippe Faure stated, "If you can't afford the safety control measures then you can't afford to do the job"[13].

This basic thought cuts across all levels and all industries.

- In product manufacture the total cost needs to include the safety costs and in turn this will influence the market price. This is what is demanded in the European essential safety requirement[14].
- When a client is buying work they need to insist that contractors include safety measures in their methods of working, however their estimate for the work must allow the contractor to put safety measures in place. The client allowing for adequate resources needs to include a realistic timescale for the completion of the work as well as suitable recompense.
- Likewise, with the service industry, schools, hospitals, government etc., there can be no cut backs on safety measures in the delivery of the services. This is particularly important when the desired outcome is the improved quality of life of millions of customers.

The partnership approach where the client, the designer, contractor, employee and end user are all working towards an agreed end is the way forward. In Ireland, in the construction industry, employers and industry federations, major clients, the regulators and the safety professionals came together recently to introduce 'Safe T Cert' to the industry.[15] Although still in it's infancy, it brings the need to establish a management system and audit protocol to the contracting firms. Many of the contracting firms are being encouraged to adopt OAC as the means of competing for this certification. Audited annually and independently verified, the process is designed to record a level of safety and monitor continual improvement. As the 'Safe T Cert' program rolls out it will raise the

[12] Palm Beach Post, June 22nd 2002
[13] ISSA Paris, Dec 2001
[14] Under normal, controlled or reasonably foreseeable conditions of use the products do not present a risk of death or personal injury to anyone keeping, using, assembling or dismantling them.
[15] The 'Safe T Cert' scheme is supported by IOSH and the International Register of Certified Auditors (IRCA)

awareness of and establish a level of competence in safety management across the industry. Since it is based on international best practice there is no reason why it should not work in other industries and other countries across the world.

**Conclusion**

OAC takes the industry back to first principles in an effort to clear away the clutter that has built up with years of risk management. The model builds upon what we all know, particular to our industry, and allows the architect of the management system the flexibility to design a program that will fit with the business and be robust enough to withstand any legislative changes or technological advances.

Within OAC the opening three questions, although simple in style are extremely powerful and probing in nature. The answers will invariably lead to a heightened awareness of the hazards and assist with the development of the management solutions. Any good safety management system relies upon quality information. There are always many competing factors that make it is easy to be swayed by a crisis or the issue of the day. Often the reaction is for managers to work to demonstrate how well they are geared up to deal with it. However the danger is that this will not achieve the desirable position of properly managing the safety of the operation on an equal basis with all the other important business areas.

An organisation's safety policy needs to reflect the nature, scale and impact of its activities across the entire spectrum of its activities. Therefore not only is it correct to customise safety policy to fit the needs of the business it is expected of any quality organisation.

This is achieved by a thorough examination of the company's present position using OAC. The first question, 'what can cause harm?', prompts the company to examine what it does and what affect it has on its workers and its surroundings, regardless of the regulatory position. This is always a good starting point in safety management since it allows the organisation to deal properly with current legislation and prepare for future requirements. Similarly the follow on question, 'what are you doing about it?', provides the opportunity to detail the actions being taken to mitigate the harm. In essence, having answered the first two questions, a hazard analysis has been carried out. Depending on the nature and the scale of the project it may be necessary to carry out a more formal or more complex hazard analysis. The opportunity can then be taken to check the regulatory position.

The concept of continual improvement is introduced into OAC with the, 'is it enough?' question. This is fundamental to good safety management since public acceptability, technical knowledge and engineering practices are in a state of continual development. By using OAC a company will easily establish the current state of its control activities.

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## Introduction - Construction Accidents

Construction sites are hazardous environments. In 2002, out of 5,524 fatalities in privates industry, 1121 occurred in the construction industry, accounting for 20% of all work related fatalities that year, with the main causes of accidents recognized as

- Falls from height (24% of construction industry fatalities),
- Struck by object (13%) and
- Highway incident (11%),

as well as health issues such as vibration, noise and dust, and exposure to harmful agents. [1]

| | Number of fatalities | Fatality rate (per 100,000 employed) |
|---|---|---|
| **Construction** | 1121 | 12.2 |
| **Transportation** | 910 | 11.3 |
| **Agriculture** | 789 | 1.7 |
| **Services** | 680 | 22.7 |
| **Manufacturing** | 563 | 3.1 |
| **Government** | 554 | 2.7 |
| **Retail trade** | 487 | 2.1 |
| **Wholesale trade** | 205 | 4.0 |
| **Mining*** | 121 | 23.5 |
| **Finance** | 87 | 1.0 |

**Table 1: Numbers and rates of fatal occupational injuries by industry division, 2002**

In addition to these figures for construction, the Federal Highways Agency reported 42,815 highways fatalities, of which 1,181 (2.8%) occurred as a result of work-zone activity.

But fatalities only reflect a small percentage of the reality of workplace safety failures. For example, in the same period over 4.7 million injuries and illnesses were recorded in the private industry sector of which almost 1.5 million involved days away from work. Over ¼ million involved falls to a lower level.[2]

[1] National Census of Fatal Occupational Injuries in 2002, DOL, Bureau of Labor Statistics Sept 2003.
[2] BLS, June 2004

Deaths and injuries in the construction industry are therefore still amongst the highest despite considerable efforts from legislators and practitioners to improve safety. On average US construction workers are three times more likely to be killed than their counterparts in all other industries, while amongst construction laborers this rate is almost seven times greater.

Applying the findings of for example Bird's research[3] into workplace accidents and his 1:10:30:300 ratio (Figure 1), the deaths and serious injuries reported above mask a picture of workplace accidents that run into the tens of millions that have resulted in injury to persons and/or property damage, with the probability of some 450 million incidents that, though they resulted in no visible injury or property damage were none-the-less close enough for concern.

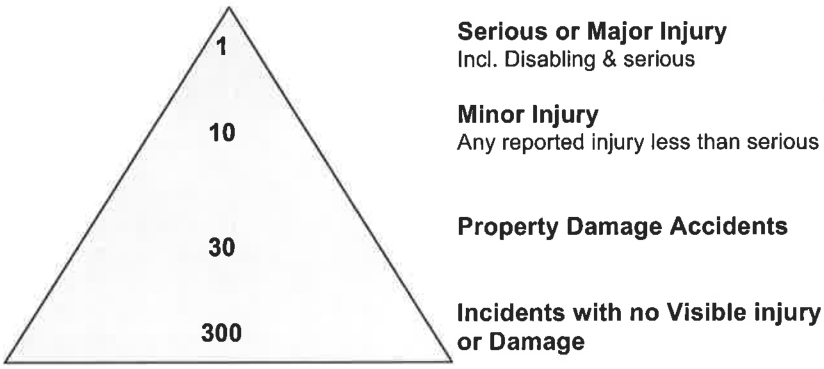


**Figure 1: Bird's Triangle**

Every incident represents a loss of control of the work operation, whether that loss is at the hands of the individual worker, or at the highest levels of the planning and design stage of the project. The UK government's National Audit Commission recently concluded that 60% of all construction accidents could be traced back to the design and decision making process (i.e. pre-construction). Illustrative of this latter point are comments by Paul Andreu, architect of the recently collapsed terminal at Charles-de-Gaulle Airport, Paris, in an interview with *L'Humanite* newspaper where told them that he "...can't explain what happened. I just don't understand it". Behind this statement lies an admission that there were unknown factors at work over which no control had been exercised.

At the International Construction Industry Symposium in 2001, it was demonstrated that every action has an outcome that is either desired or a multitude (theoretically infinite) of undesired outcomes. It was concluded that absolute control equates with absolute certainty of outcome.[4] In Paris, as in

[3] Frank E. Bird, Director of Engineering Services, Insurance Company of North America, 1969
[4] McAleenan & McAleenan, Operational Analysis & Control Model, ISSA, Paris 2001

many other work operations, ignorance of key elements of the operation/process reduced the control and introduced uncertainty into the final outcome.

The National Institution for Occupational Safety and Health (NIOSH) refers to accidents as 'preventable injuries'[5], a useful definition to bear in mind when considering dynamic safety management. Therefore, the question for the construction industry is;

> Why do we accept all these deaths, injuries and incidents of ill health when we have the technological and intellectual capability to prevent accidents?

The basic premise for construction projects is that they should be designed, built, maintained and eventually demolished in a manner that does not cause harm to the construction personnel, maintenance operatives, end users and demolition specialists The operational analysis and control (OAC) model[6] is used as the basis for developing an audit controlled, designers checklist that translates to an on site H&S plan for construction workers. In the process the case for independent checking of design and construction firms against international best practice and a solution for auditing their compliance with the standards is presented.

## Fundamental Principles of OSH

### Legislation – The Intent

Everyman owes his neighbor a duty of care in respect of any action or inaction on his part that has a direct effect on that neighbor. This principle is a common law duty that has over the years been tested and expounded in the courts and is the foundation for many legislative acts that quantify the specific legal duties one person owes to another in respect of their many and complex dealings. Applied to occupational safety and health, the intent of legislation is to ensure that those who work are assured as far as possible of safe and healthful working conditions.[7] At the core of this it is a requirement for employers is to provide work places and environments that are free from recognized hazards that cause or are likely to cause death or serious physical harm to employees.

This law is supplemented by codes and standards that provide specific details on how the fundamental duty may be met in regard to specific work operations and industries.

[5] Becker P, Lecturer WVU, private conversation with one of the authors (ISSA Paris December 2001).
[6] McAleenan, C & McAleenan, P. "A Different Approach – OAC", NSC 2002, San Diego.
[7] 2(b) OSH Act 1970

## Corporate Governance

But it is not just the law that recognizes that in our dealings with each other we must have due regard to the potential for harm inherent in our activities. The OECD Principles of Corporate Governance state "...boards are expected to take due regard of, and deal fairly with, ... stakeholder interests, including those of employees, creditors, customers, suppliers and local communities".

There is therefore a moral, legal and principled obligation to conduct our affairs in a manner that will prevent harm or injury to others, and this obligation extends to the way in which we design, construct, commission maintain and eventually demolish our buildings and engineering projects. Design quality; that combination of functionality impact and build quality incorporates the key requirements of all the stakeholders, business and whole-life value in relation maintenance, management, flexibility, health and safety, sustainability and environmental impact.[8]

## Basic Engineering Principles

The success of any construction process begins with the client and his willingness to commission a project that will bear the test of time and stand acknowledged by present and future generations as a symbol of excellence in the built environment. The translation of that desire into preliminary drawings, detailed plans, construction and eventually to the finished project will fall to competent advisors; the architects and designers, engineers and principal contractors. The relationship between these players (which we shall explore in detail later in the paper) is crucial to the successful implementation of the client's wishes. It has been said that the million-dollar mistake can be traced back to these early stages in the design process and the decisions made at the first scribbling of the design, whereas with early identification and correction, using a structured design checking process the costs would be marginal, by comparison.

Designers are in a unique position to eliminate or reduce the risks that arise during construction work and have a key role to play in the design and management of construction projects. The earliest design decisions can fundamentally affect safety and health. It is tasked to the designers and engineers to advise the client on the feasibility of his project and the resource requirements to make it work. Behind any project there are fundamental principles that are universally applicable and which the designers and engineers must keep to the fore from the outset.

Construction projects, whether public works or private developments must demonstrate adherence to the key engineering principles;

[8] Achieving Excellence in Construction, Procurement Guide 09, Office of Government Commerce, UK, 2004

- Fitness for purpose
- Buildability/ constructability
- Maintainability (including emergency preparedness and security)
- Demolition & disposability

**Fitness for Purpose**

When considering a building for example, Fitness for Purpose has different elements, and different ways of interpreting those elements depending on the nature of the building and the functions to be carried out within. A warehouse will differ from a school, which in turn will differ from a hospital, and that again will differ from a stadium.

Some buildings will have a single function for the duration of their useful life, whereas others will under-go changes of function over time. At the design stage it may not be possible to foresee possible uses to which the building may be put at some unknown future date, but nonetheless change of how it may be used even within a single function can be planned for and incorporated into the design. For example in Stranmillis College, Belfast a library was located on the top two floors of a tower block before it was realized that the point loading on the floor was too great. The library was relocated to the ground floor and the upper floors are now used, more appropriately as lecture halls.

- Space within and around the building should be designed with efficiency in mind. People, vehicles and product should be able to move freely from one point to the next without unnecessary obstruction or meandering.
- Space should also allow for maximum flexibility in layout.
- There should be clearly defined places for all the different functions users will require, entrances, reception areas, places for work, breaks, catering, hygiene requirements.
- The building or structure should be accessible to all. Travel from one level to another should not present an obstacle with color and texturing of surfaces designed to aid navigation, and the use of induction loop audio systems for those with hearing impairments. Even the location of the building/structure within the built environment should not prevent access. Where relevant it should be welcoming to the public and customers. It should represent the organizational values both in terms of design and location, e.g. a school should be experienced as a place for learning, growth and development, a hospital as a place of caring and healing. Other factors to consider include;
- Internal environment, light, heat, air etc. should be of good quality and individually controllable where possible.
- Comfort and ergonomics.
- Color, texture, light and architectural features to enliven the environment. This enhances both the welcoming effect presented to the public as well as reducing workplace stress.
- Security and safety

- Energy efficiency and future proofing.[9]

Finally in the case of buildings will the users; particularly those who work there have access to views and outlook? In the above it is evident that the functionality of the project must be clearly established in advance of the preliminary drawings being developed and, where possible, even before the site is acquired.

**Buildability/ Constructability**

Buildability or constructability is an assessment of the construction sequencing and key actions involved in building operations and works of engineering construction that enable efficient and safe management of the construction process, without detriment to occupational safety and health or the environment. A successful project has to be buildable. The factors here to be considered are primarily engineering, but also ones into which the principal contractor must input his knowledge and expertise. The desires of a client and designs of his architect must not be allowed to take off in flights of fancy without the engineer's sober assessment of the safety of those designs.

Construction projects must therefore be;

- Technically feasible,
- Safe to construct, and
- Capable of being carried to completion within the resources allocated.

Technical feasibility takes into account the built components of the project as well as the environment in which it will be sited. All things being equal, the shape, size, height and appearance of the project must be capable of being realized within the current level of technical knowledge of the builders and the physical capacity of the materials to be employed in the construction. The mile-high building is the ambition of some visionary architects and engineers, but there are also many who would argue that we are currently on the point of absolute limit in buildings in Taiwan and Malaysia and proposed new WTC in New York.

Notwithstanding the conceptual potential of the project, in reality it will not stand in abstract relationship to its environment, and its feasibility will be effected by the geology of the site, the climate, proximity to other human and physical features, even social, political and economic factors may effect both the capacity and desirability to build.

The Taipei 101 Tower in Taiwan has been designed and is being constructed to exist within an unstable geological region, one prone to earthquakes, and one that is also subject to typhoons. To achieve stability in the building and counter movement, engineers have incorporated a tuned mass damper system that

[9] Further information from the Commission for Architecture and the Built Environment, http://www.cabe.org.uk

transfers energy from the building to a swinging sphere thus providing the stabilizing force. However, despite the foresight of the designers regarding the security of the finished structure, in March 2002, halfway through the construction phase an earthquake measuring 6.8 on the Richter scale rocked the structure causing two tower cranes to collapse. A valuable if late learned lesson that nature does not act in compliance with safety standards[10]. The final structure may well withstand the elements but the standards clearly were not applicable to the construction phase.

In California the Transportation Department has introduced a formal Constructability Review Process (CRP)[11]. CRP is an iterative, multi-disciplinary review of the PS&E at various defined stages of the project development process. The review includes all functional areas including, but not limited to: traffic, design, construction, and maintenance. The CRP has been implemented on all projects greater than $25 million since July 1997 and will be implemented for all major projects (>$750,000) by July 1998. Constructing a project right the first time will not only minimize contract time, but also reduce or eliminate some future maintenance problems. All of this adds up to less inconvenience to the traveling public and a better perception by the public of the State DOT.

Refer to Appendix 1 for further detailed examples of structural failures.

**Maintainability (including emergency preparedness and security)**

Designing for and safely completing the construction phase is not the total extent of the designers and engineers role in a structure. Once the client has accepted responsibility of the completed project its maintainability is a central consideration in both the short and long term use of it. Referring to Taipei 101 again as an example, in May 2004 a further crane incident occurred and on this occasion maintenance workers had a lucky escape when, “for unclear reasons” a four-storey crane shifted during an operation to change light bulbs on the external wall of the tower.[12] Damage was done to a connecting bridge between two buildings causing it to be closed by inspectors.

It is clear from this example that maintenance requirements can give rise to substantial hazards that have the potential to injure workers and the public, to damage the primary structure as well neighboring structures, to interrupt industry and commerce, disrupt the functioning of urban and rural transport systems and infrastructure and cause public and political discontent.

[10] See Taipei Times, http://www.taipeitimes.com/News/front/archives/2002/04/02/130157
[11] Source: http://ops.fhwa.dot.gov/wz/practices/best/view_document.asp?ID=23&from=topindex&Category_ID=90
[12] ibid. http://www.taipeitimes.com/News/taiwan/archives/2004/05/20/2003156219

Engineers have been criticized for developing ingenious solutions to problems but have a tendency to fail to take account of the safety issues that will be faced by maintenance technicians who may have to climb to unsafe heights, traverse fragile surfaces or enter restricted crawl ways in order to carry out basic maintenance activities on pipelines, cables, switch points, light fittings etc.[13] This may be an unfair generalization but it indicates that health, safety and welfare issues occur throughout the whole life of the structure and must be considered integral to and an essential requirement of the design process.

## Emergencies

The tragedy of the World Trade Center in 2001 illustrated, all too painfully, that the greater the structure the greater the potential for disaster should anything go wrong, whether deliberately carried out or resulting from natural causes or engineering failures.

Though the specific incident that caused the collapse of the towers was not foreseeable by the designers, the fact that tall buildings come down in unplanned circumstances was known, and there were enough examples in real-world circumstances to support this, as well as hypothetical situations that designers are well able to envisage. Likewise bridges come down, dams collapse and whole cities can be devastated within a very short space of time. And though at this level of control failure it may not be technologically possible to prevent the loss of the structure, designers and engineers must be considering the means to mitigate human loss should an event of this nature occur, or advising the client that the project is not feasible in the first instance.

In recent years two tunnel emergencies hit the headlines in Europe, both involving train fires in tunnels connecting neighboring countries, the Mont Blanc Tunnel under the Alps in France and the Channel Tunnel under the English Channel. The former ended is a massive tragedy with the loss of many lives; the latter had the same potential.

Tragedies like these gain worldwide notoriety because they are large scale, spectacular and, for macabre reasons in the human psyche, involve or have the potential to result in multiple fatalities. But it must be remembered that day and daily many small scale, individual accidents and emergencies occur in construction projects that in the scale of things result in much greater annual loss of life or long term injury and disability.

Thus client, designers and engineers must give due consideration to emergency preparedness and maintenance at the briefing and design phases of the project. All the safety issues for keeping the structure functional throughout its life, for responding to emergency events, large or small, and for upgrading and improving the structure are on the table from the outset. Hazards are identified at this stage

[13] Stated to the authors by technicians undertaking advanced training, Dublin 2001

and are engineered out as far as is technologically possible, and appropriate alternative control mechanisms build into the design to prevent employee and public exposure to harm.

**Demolition and disposability**

Notwithstanding any unplanned event that will cause a structure to come down in an untimely and uncontrolled manner, all structures have a functional life that will eventually end in its controlled demolition. For many modern structures a 100-year life would not be an unreasonable expectation. The safety issues will include;

- The impact of the demolition on the neighboring environment,
  - Includes method of demolition, plant and equipment to be used.
- The environmental impact associated with the disposal of the debris,
  - Volumes of debris.
  - Location of and transport to tip sites.
- The removal and disposal of hazardous materials from the structure.
- The demolition sequencing, particularly important with pre-stressed or post-tensioned concrete structures.
- The safety of operatives involved in the demolition and removal.

It is not appropriate for the client or designers to assume that this will be a problem for future generations to solve. If they fail to take it into consideration it will be such a problem, but it is incumbent upon the generators of a project of this nature to foresee the problems and to design out the hazards associated with demolition and disposal, or engineer in effective controls that will ensure that the structure can be taken down and removed in a safe and healthful manner.

**Design Safety Analysis and Control:**
**Core Principles**

The core principle is that construction projects can and should be designed, built, maintained and eventually demolished in a manner that does not cause harm to the construction personnel, maintenance operatives, end users and demolition specialists.

Some hazards can be eliminated or contained through good engineering design solutions and others, inherent in the process, have to be worked around. In all cases it is essential to identify at the earliest opportunity what hazards exist, the harm that can result and how it does so.

Fundamentally this necessitates a full analysis of the design safety issues and the development of appropriate controls to ensure that work operations during the construction phase proceed in a manner that make certain that people, plant and property are protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced. On the interface between client, designer, engineer and contractor this requires the acceptance of project objectives that include tasks/ activities being completed on time and in a manner that does not cause harm to the employees, customers, other non-employees, or the company.

The operational analysis and control model (below) integrates all aspects of the project process including those associated with the design elements in construction. Underpinning this approach to safety is the elimination of risk through the absolute control of all stages of the process.

The model suits the requirements of European Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites with particular reference to project preparation.

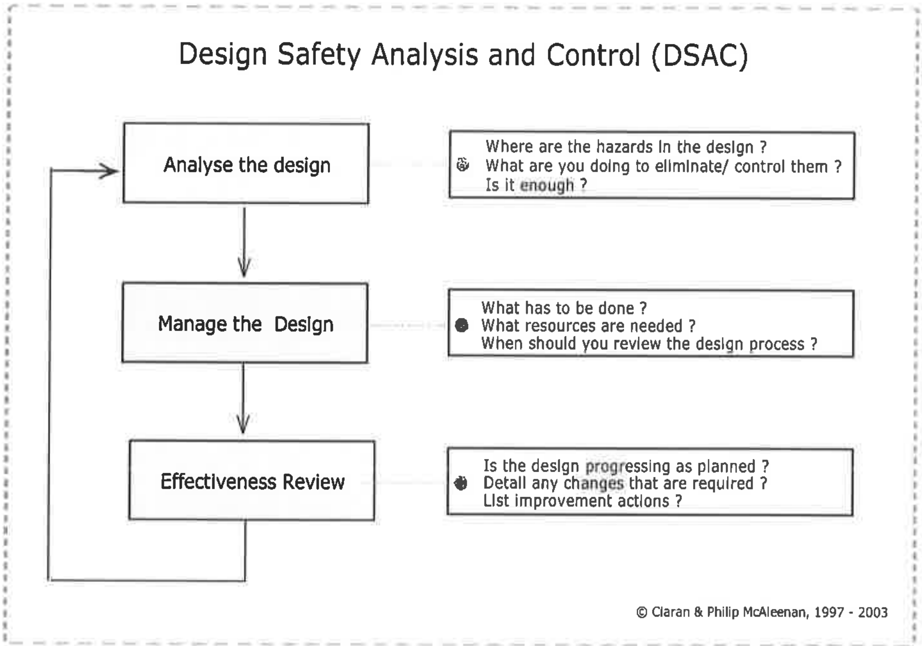


**Figure 2: Design Safety Analysis and Control (DSAC) Model**

There are three stages to the design analysis and control model as follows

**Stage 1 – Design Analysis**

Hazard identification commences when the project is first proposed; the ideas of the client, the location chosen (if already done so) and the financial resources that he makes available are the beginning of the process all impact upon the construction and whole life safety of the project. A preliminary assessment of requirements against resources at this stage by the designer will identify any hazards that may render the project infeasible or require project modification in order to make it feasible.

It is the designers' and the engineers' tasks to identify what hazards are presented by the design, the location, the environment, and the materials to be used for any factors in the design that can cause harm. As the project develops and the design is modified, other factors become relevant, e.g. methods of construction, the workforce, and plant and equipment.

In each of the different phases in the building's life, from construction, to occupation/maintenance and finally to the demolition phase, there are hazards with the potential for harm. Good design principles apply at all stages from the initial building design to the design and erection of scaffolding by contracted in firms.

Critically the process of assessing the hazards that exist is not concerned with the reduction of the risk posed by them, but in this model is focused on the elimination of the risk by appropriate and sufficient control mechanisms. The key players at each stage of the project must consider what has to be done to prevent harm occurring? Once it is known what can cause harm, the designers' and engineers' must look for the controls that are needed to prevent that harm occurring.

Elimination is the first objective and it may be necessary to go back and review the designs.

If the hazard cannot be eliminated, then consideration must be given to all alternative control measures necessary to prevent the harm being realized. Whatever control measures are selected, they must be sufficient to eliminate/control the hazards described?

Table 2 below illustrates examples of the hazards and design solutions that may be appropriate.

**Table 2 – Sample Designers Checklist** (Apply appropriate International Standards)

| Phase | Hazards / Harm | Design Solution (Note whether it eliminates, contains or controls the hazard) | Information required for (Insert: construction safety plan and/or client safety file)[14] |
|---|---|---|---|
| **Construction** | • Bridge construction, working at heights | • Pre-assemble spans and raise to position (eliminates a substantial amount of work at heights) | • Construction safety plan |
| **Occupation & maintenance** | • Painting exposed steelwork (e.g. bridges)<br>• Pipe and cable maintenance or replacement<br>• Fragile roof | • Use weathering steel (eliminate need for painting)<br>• Lay pipes and cables along accessible routes (eliminate need for heights)<br>• Construct and mark permanent walkways, erection of barriers, warning signs (contains) | • Construction safety plan<br>• Construction safety plan and client safety file<br>• Construction safety plan and client safety file |
| **Demolition** | • Pre-stressed concrete supports | • | • Construction safety plan and demolition sequence in the client safety file |
| Note: This table is simplified, incomplete and is included as an example to illustrate the DSAC process | | | |

[14] Construction Safety Plans are dynamic documents that describe the measures necessary for ensuring safety at all stages of construction. Client Safety Files are files produced at the end of the construction phase and are intended for use by the client during the occupation/maintenance and demolition phases of the project.

At the design stage, and before embarking on the work operation, it is important to consider whether enough has been done to prevent harm.

There are limitations to the knowledge of any one individual and it imperative that specialist advice and where necessary cross-checking is sought from, for example the project coordinator, other designers and architects, contractors, manufacturers and suppliers of materials, plant and equipment, OSHA, trade or professional associations, other safety professionals etc. In this way the designer and the client can be assured that national/ international design standards are being applied.

In the UK, the Design Manual for Roads and Bridges includes a technical approval process that requires independent engineering checks that all standards have been applied, including buildability, constructability and safety.

Things can go wrong and it important to try and anticipate what they may be as early as possible. Designers must ask themselves;

- What could go wrong?
- How could it happen?
- How should it be dealt with?

Asking the questions at the outset focuses the mind and ensures that all the foreseeable incidents have been considered and planned for. These questions also prompt consideration of those emergency plans that are required to be in place prior to starting any particular operation.

**Stage 2 – Design Process Management**

Having carried out the analysis a list of what has to be done to ensure a safe outcome to the construction, use and demolition of the building must be drawn up, e.g.

- Has the client, the project coordinator and contractors been made aware of what can cause harm and what they must do?
- Is it known what specialist skills are needed at different phases in the life of the building?
- Are there written safety instructions?
- Does everyone know who is responsible and for what?
- What resources are needed? (Material, technical, human, financial).

It is important that, having identified the resources, that they are made available. Controls and the resources necessary for their implementation must be built into the budget and business plan.

It is worth considering some of the issues here.

## Material and Technological

Some resources will be needed well in advance of any work operation. Others will require ordering up again well in advance of them being needed, e.g. custom designed tunnel boring equipment that may take a year and more to be designed, manufactured and tested before delivery to the site.

All materials, plant and equipment that are to be used in the construction or the occupation phases must be selected and acquired with care. It must be suitable for the purposes intended, meet any national or international standards that are applicable, and, importantly, safe in its normal use.

## Human

Human resources in any project, from the appointment of the initial designer to the employment of site laborers, must be engaged on the basis of their competence (or agreement to undertake appropriate training) to do their job.

The term "Competent Person" is used in many OSHA standards and documents. As a general rule, the term is not specifically defined, though in a broad sense, an OSHA competent person is an individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions (see 1926.32). Some standards add additional specific requirements that must be met by the competent person.

OSHA's list of interpretations includes the following;

> For the purposes of OSHA's safety and health standards for the construction industry, "competent person" is defined in 29 CFR 1926.32(f) as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them." This definition is further clarified in the preamble for the rulemaking on excavations (FR 54 45909) issued on October 31, 1989. That preamble states that what constitutes a "competent person" depends on the context in which the term is used. In order to be a "competent person" for the purposes of the excavation standard, one must have specific training in, and be knowledgeable about, soils analysis, the use of protective systems, and the requirements of the excavation standard. One who does not have this training or knowledge is not considered by OSHA to be capable of identifying existing and predictable hazards in excavation work nor capable of taking the necessary corrective measures. By contrast, a "qualified" person or engineer, as defined in 1926.32(l), might have more

technical expertise, but would not necessarily have expertise in hazard recognition or the authority to correct identified hazards. [15]

Knowledgeable and authorized to act are the key components of competence, and there is no doubt that these are important indicators to a persons likely competence, but as a definition of competence they are inadequate, and as a measure, not sufficient in themselves.

A more appropriate definition of competence would be *the consistent skilful application of skills and knowledge to any specified work operation* (at whatever level that may be within the company), where the use of the term skilful implies conducting the operation to the highest standards within the field.

In this respect a competent designer is one who consistently produces structural designs that can be built, maintained and demolished without causing harm (in its widest sense) or hurt to construction/ maintenance workers and end users.

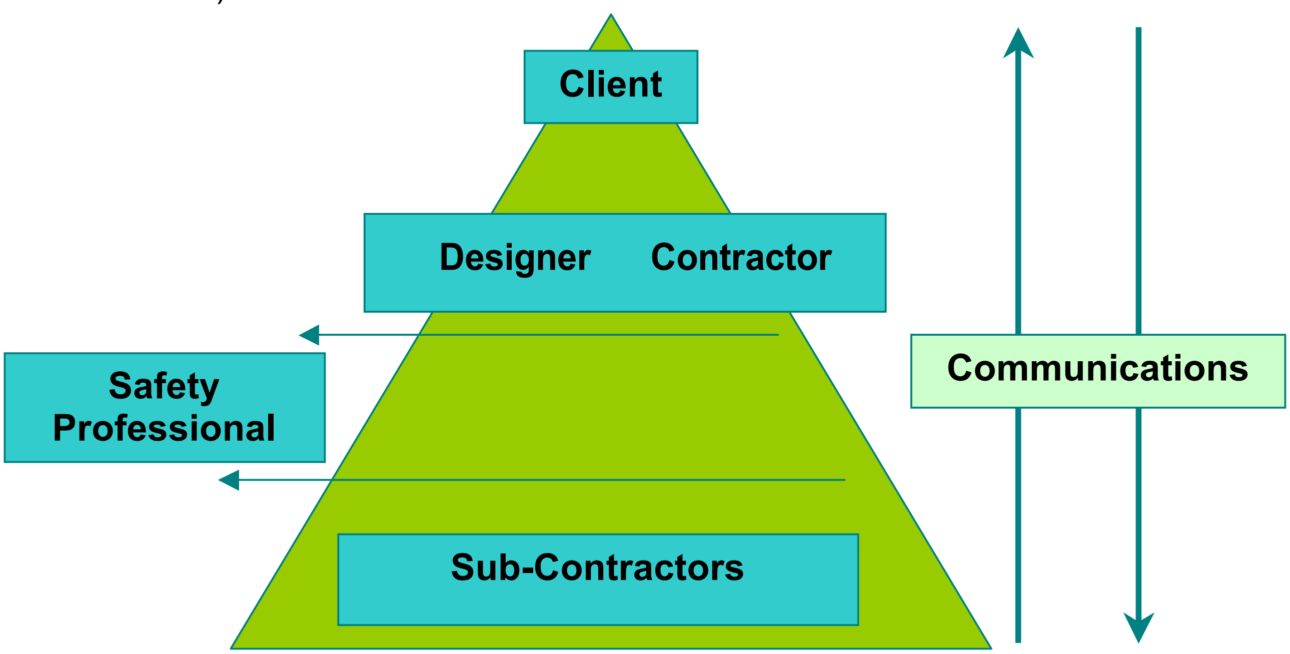


**Figure 3: Relationships Model**

Integral to this concept of competence is the notion that, having regard to the designer's age, experience and skill they will know of the hazards and apply the controls necessarily associated with the work.[16]

Importantly, the thread of competence extends throughout a company; subordinates, supervisors, managers and executives, each level skillfully

[15] Source: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=20625

[16] See Dalton v Frendo (1977), Irish Supreme Court.

applying their knowledge and skills to the successful completion of their particular work areas (Figure 3, above).

Ultimately, in the design process, competence begins with the client who must ensure, through reasonable enquiry and by seeking advice, that the designers and engineers he engages are themselves competent to assess his project and to advise him accordingly on the health and safety issues. He must also ensure that they are well enough resourced to undertake the duties he requires of them, that they can demonstrate a successful track record in similar work and that they can and will act in compliance with their legal duties for health and safety.

Where it is necessary and appropriate to do so, a competent safety professional may be engaged to advise on aspects of health and safety in the construction of the project. Sometimes referred to as a planning/ project supervisor[17] or coordinator, his task is to ensure that all the safety issues have been considered and adequately dealt with by the managers and supervisors at each level.

A clear delineation must be made between the safety professional's role as an advisor and the managers' and supervisors' responsibilities to manage safety and ensure that they and their subordinates are compliant. Safety of the project commences at the strategic level and develops throughout the design process to the specific health and safety plan that implemented at all levels.

Each player in the process has clear roles and responsibilities (Table 3). The relationship between client, designers and engineers and contractors is a cyclical one where the exchange of information and advice between one party and the next is crucial to the development of the safety plan and the successful outcome of the project. In respect of safety their roles can be summarized as follows;

| **Table 3 – Roles and Relationships** | |
|---|---|
| **Client** | - Timing and resourcing the project |
| **Designer** | - Engineering out, or elimination of major hazards and maintenance hazards |
| **Contractor** | - Eliminate of hazards, barrier to construction phase hazards |
| **Sub-contractor** | - Barriers, Safe Working Procedures |
| Note: There are some overlaps with the above) | |

[17] EU Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at mobile construction sites.

 

Thus the process of identifying and selecting on the basis of task requirements and competence applies throughout the project whether selecting designers and engineers, or contractors and employees. It applies to all parties in the process and requires a sufficient degree of managerial competence itself to make is successful. Anything less will introduce hazards to the project and the higher up the system it occurs the greater the harm to the project.

**Stage 3 – Design Effectiveness Review**

Designs need to be reviewed. Believing that a design is safe is a sure way of ensuring that it is not. Like every aspect of work safety needs to be continually managed and improved, as necessary. It is important therefore that a time or circumstance is set for reviewing the effectiveness of the management controls.

The review could be triggered;

- When new processes or new equipment are introduced to the operation.
- When new techniques have been developed.
- When statutory obligations require it.
- When resources inputs are set to change.
- When an accident or incident occurs.
- When the site is handed over.
- When maintenance, renovation, demolition is planned.
- At regular intervals (determined by the nature and complexity of the hazards present).

Note: The list above is not exhaustive. An effectiveness review should be carried out at any other time, should it be warranted.

Potentially there are many design issues involved in each phase of the life of the building. The designer of the project has a responsibility to consider how these design issues will evolve after the client assumes ownership. It is important to ensure that these progress as planned, and here a project coordinator plays a vital role. Designs change, as does the use of the building. Designers and engineers need to be aware of the effects of any change and try to anticipate how they will need to be dealt with. Consider the following questions;

- What new design solutions result from the review?
- What effect will it have on the project?
- How will it be dealt with?

If nothing has changed then it may be sufficient to note that the review has taken place and set the next review date. If design changes are necessary, they should be itemized in the designer's checklist (see above) and consideration given to what information needs to be included in the safety plan and the safety file.

Any improvement actions should be listed, an action plan developed, resources implications identified, persons responsible for completing the actions nominated and the timescales for completion drawn up.

The review process is also the commencement point for learning transfer. Solutions developed in one design are capable of transfer to new designs for other projects. The concept of foreseeability is an intellectual skill in the direct application of or deduction from knowledge from prior experiences to future situations. It we can draw on past experiences on what can go wrong, likewise we should be drawing on past successes in preventing injury and harm.

**Summary**

The design safety analysis and control process is concerned with the identification of hazards in construction projects and the development of sufficient control measures that will ensure that no harm comes to anyone effected by the project, whether employee, end user or member of the public. Recognition that hazards exist is the commencement point. What we want to achieve is the identification of the harm that can result and the development effective controls to prevent that harm being realized. These controls constitute the safety barrier between the hazards and the operator/end-user.

This barrier is the development of a number of suitable and sufficient mechanisms that may include one or more of the following;

- Eliminate the hazard
- Reduce the hazard impact potential
- Control and residual hazards by alternative means
- Information to operators and Safe Working Procedures

The outputs of the DSAC process are a Designers Checklist and an effective health and safety plan that ensure a safe and healthful work environment.

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June 24 2004

## Appendix 1: Table of Examples of Structural Failures
Source: www.icivilengineer.com

| Engineering Failure Watch |
| --- |
| Roof Collapses at Paris Airport **May 23, 2004**<br>A 120-foot section of a new terminal at the Charles de Gaulle international airport here collapsed early Sunday, killing at least five people, injuring seven and burying an unknown number of others.<br><br>Girder collapse in Colorado **May 15, 2004**<br>A 40-ton steel girder dropped from a freeway overpass construction site into morning traffic, crushing one car and killing all three people inside.<br><br>Four Construction Workers Died after Crane Collapse in Toledo, Ohio **February 16, 2004**<br>Three iron workers were killed and five injured Monday afternoon in the collapse of a crane on a construction site outside of Toledo, Ohio.<br><br>Crane Collaped in Stratford Bridge Project, Killing the Crane Operator **February 16, 2004**<br>A $96-million bridge replacement job in Stratford, Conn., two barge-mounted cranes collapsed, killing the crane operator.<br><br>Moscow Roof Collapse Kills 21, Hurts 106 **February 14, 2002**<br>The snow-covered glass roof of a Moscow water park collapsed Saturday evening onto hundreds of people, killing at least 21 people<br><br>A Partially Finished Bridge Collapsed in California, USA **December 3, 2003**<br>An approximately 100-foot section of a partially finished bridge collapsed, killing one worker and injuring seven others.<br><br>A Casino Garage in New Jersey, USA, Collapsed **October 30, 2003**<br>The top five stories of a parking garage under construction at a casino collapsed. Three people were killed.<br><br>Flooded Subway Project Causes Subsidence in Shanghai, China **July 1, 2003**<br>An underwater tunnel connected with Shanghai's planned fourth subway line has collapsed, causing several buildings to tilt and subside.<br><br>Rhode Island Nightclub Fire **February 21, 2003**<br>A pyrotechnics display ignited the stage of a Rhode Island nightclub, which caused the blaze to spread throughout the building. At least 98 people were killed and 160 injured.<br><br>South Korean Subway Fire **February 18, 2003**<br>A formal mental patient set fire to the packed subway train in Daegu, South Korean, killing up to 200 people.<br><br>Chicago Club Fire **February 17, 2003**<br>At least 21 people were killed at the Club when they panicked and tried to escape a fight.<br><br>Building Collapsed in San Antonio **December 4, 2002**<br>A five-story building collapsed in downtown San Antonio, 3 people injured.<br><br>A Schoolhouse Collapsed in An Earthquake in Italy **November 1, 2002**<br>26 children were buried in the collapsed house while most of nearby buildings stand. |

N.Y. pedestrian bridge collapse **October 10, 2002**
A pedestrian bridge under construction collapsed as concrete was being poured onto its steel girders, killing one worker and injuring 10 others.

Panels and roofing metal collapsed in Western Australia **September 2002**
A concrete "tilt-up" slab at a Western Australia construction site crushed, killing a construction worker.

Miami bridge-tower collapses **July 15, 2002**
The control tower on the Flagler Street bridge in Miami collapsed, injuring a woman.

A Dam in Northern Syria Collapses **June 4, 2002**
A dam in northern Syria collapsed, killing at least two people.

Apartment building in St. Petersburg collapses **June 3, 2002**
A nine-story apartment building in St. Petersburg collapses, killing three people.

Russian Cosmodrome Roof Collapses **May 12, 2002**
Part of the roof of Russia's space launch complex in Kazakhstan has collapsed, injuring at least eight people.

Beirut Building Collapse Kills Four **March 23, 2002**
A seven-story building collapsed into a pile of rubble Saturday, killing four people and crushing cars.

Falling Scaffolding in Chicago Killed Three People **March 9, 2002**
Scaffolding from the 43rd floor of John Hancock Building fell to the downtown street, killing three people.

Convention Center Girders Collapses in Pittsburgh **February 12, 2002**
Steel girders collapsed at the David L. Lawrence Convention Center under construction, killing a Moon ironworker and injuring two others.

Scaffolding Collapsed at A Manhattan Office Building **October 25, 2001**
Five construction workers were killed and 10 others were injured when a scaffold collapsed at a Manhattan office building.

Wedding Hall Collapses in Jerusalem **May 24, 2001**
An over-crowded wedding reception hall collapsed Thursday night in Jerusalem, killing at least 25 people and injuring 250.

Steelwork Collapses at Convention Center Site **April 17, 2001**
Part of the new D.C. convention center collapsed.

A Bridge Collapse in Portugal Kills up to 70 People **March 4, 2001**
A 116-year-old bridge in Portugal collapsed. One of support pillars gave way under pressure from river water.

Selby rail disaster **February 28, 2001**
Caused by a piece of metal from a Land Rover which had plunged onto the track falling onto the line, the accident killed 13 people, injured a hundred.

Dulles Airport Tunnel Collapse **November 1, 2000**
Part of a pedestrian tunnel under construction at Dulles International Airport caved in trapping a worker in the rubble.

Construction Trench Collapsed in Texas, USA **October 28, 2000**
A construction trench collapsed, killing three workers who were buried in 14 feet of dirt.

**Hatfield Rail Crash October 2000**
A high-speed train crashed north of London that killed four people and injured 34 put the safety of Britain's railways in question on Wednesday.

Kansai International Airport **October 2000**
Six years after its completion, Japan's second-largest airport is sinking into the ocean much faster than expected.

High School Gym in Cleveland, USA **October 6, 2000**
The roof of a high-school gym collapsed in Cleveland, Ohio injuring three students and two adults.

**Building Collapse in India September 2, 2000**
Twenty-three people are reportedly killed in a building collapse in Tundla, India.

**Moscow's Giant TV Tower Collapse August 28, 2000**
Completed in 1967, the Europe's Telecommunications tower's exposed pre-stressing cables inside are vulnerable to blaze.

SW China Bridge Collapse **August 22, 2000**
A newly built pontoon bridge collapsed in Luzhou, a city in Southwest China's Sichuan Province, killing at least two people.

**Wall Collapse on Construction Site, Maryland, USA August 16, 2000**
Two people were killed and three others were hurt when an eight-inch thick cinder-block wall collapsed at a construction site in suburban Baltimore.

Winery Terrace Collapse in Ohio, USA **July 2, 2000**
A terrace loaded with tourists collapsed at an island winery in Lake Erie, Ohio, USA

**Overpass Collapse Shuts down Quebec Highway June 18, 2000**
A huge concrete beam fell on the vehicle as it was passing under the viaduct.

Millennium Bridge Sways **June 12, 2000**
This newly completed bridge in London had to be closed because it swayed.

Speedway Bridge at North Carolina, USA **May 20, 2000**
A concrete pedestrian walkway spanning a four-lane highway in front of the speedway collapsed, injuring more than 100.

## Appendix 2 – Construction Safety Plan (Non-exhaustive Sample layout)

| Client | |
|---|---|
| Describe the project, including details of client, designers, and contractors | |
| List any existing safety information that would impact on design or construction of this project | |
| Arrangements for exchange design information between designers and contractors. | |
| Arrangements for liaison between designers and contractors. | |
| **Designer** | **Contractor** |
| Safety goals for project. | Safety goals for project. |
| Authorizations and permits required. | Management structure for project. |
| Emergency procedures. | Worker consultation/ communication. |
| Construction site rules. | Selection and control of sub-contractors. |
| Adjacent activities. | Site security. |
| Security arrangements. | Welfare facilities. |
| Environmental restrictions and existing on-site risks. | Accident recording/ investigation. |
| Significant designs and construction hazards. | Fire safety and emergency evacuation arrangements. |
| Construction and/ or demolition sequencing. | Arrangements for controlling safety hazards including method statements. |
| Materials requiring particular precautions. | Arrangements for controlling health hazard |
| Future maintenance/ safety file information. | Gathering and supply of data for maintenance/ safety file. |
| Any other relevant information either party deems necessary to ensure safe construction/ maintenance or demolition of the structure/ building | |

**Title**

Highway Work Zones - A Safe Method of Working

**Session #**

119

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## Abstract

Will anyone approaching temporary traffic control operations in highway work zones, from any direction, understand exactly what is happening and what is expected of them? In recent years, with the updating of the Federal Highway Administration's Manual of Uniform Traffic Control Devices (MUTCD there has been an upsurge in interest in safety at highway works zones. Construction workers have been killed at temporary traffic control operations and many more have endured "near misses". There is an increasing co-operation between highways Client organizations and the statutory safety bodies to establish good working practice guidance. The issues that they encountered include;

- Planning issues; including the timing of temporary urban traffic control operations, working in narrow central reserves, safe taper positions and the use of variable message signs,

- Vehicles issues; including improved vehicle specifications, impact protection for traffic management vehicles in live traffic lanes and special vehicle adaptations for traffic coning operations,

- Workforce issues; including crossing live traffic lanes, operator competence, high level visibility for and safe working methods, and

- Signing Equipment issues; including consistency and accuracy of signing, sign maintenance and inspections.

Everyone involved in this aspect of the construction industry must play their full role in identifying the dangers and specifying how these are to be controlled.

In this paper the authors examine the nature of the hazards faced by highway and street construction workers and using the operational analysis and control (OAC) model[1] will set out a safe working method linked to the MUTCD.

## Background

### Infrastructure

There are 4 million miles of streets and highways in the US, plus 600,000 bridges. With much of the highway infrastructure approaching the end of its service life the job of maintaining them in a safe and serviceable condition is ever increasing. The Transportation Equity Act for the 21st century (TEA-21)[2] authorized approximately $80bn for highway and bridge construction work between 1998 and 2003. The majority of the capitol spend focused on system

[1] OAC introduced to ISSA 2001 Paris by the authors and further developed at NSC 2002 in San Diego.

preservation resulting in increased opportunity for the traveling public to interface with highway work zone operatives.

The US government's twin pronged approach to highway safety; mobility and safety the pressure is on the industry to maintain the network with the minimum of impact on the traveling public. Accordingly competence, adherence to safe methods and innovation (both in design and in operations) has to be the order of the day if we are to safeguard highway and street construction workers. Since mobility appears to have a higher priority with legislators and statutory agencies the challenge is out there for the safety engineers to lead the way on highway work zone safety.

**Congestion**

From the 1980's through to the end of the 20$^{th}$ century lane miles across US increased by 2.4% yet vehicle miles traveled increased by a staggering 80%. The "rush hour" as it is affectionately referred to lasted for almost 3 hours in the early 1980s rising to a peak of 6 hours by the year 2000. Consequently the window for working, without significantly impacting upon the mobility of traveling public, is closing.

Department for Transportation data indicates that 20% of the national highway system is under construction in the summer months, which equates to approximately 6200 lane miles and an estimated 6500 work zones. About one third of the active work zones are operational during nighttime hours.

**Workers**

The pressures associated with the aging infrastructure and heavier traffic patterns will invariably have a massive impact upon the safety of highway work zone operatives. In January 2004 the FHWA's Office of Safety reported that a total of 42,815 deaths had occurred on highways in the United States during the 2002 calendar year. Almost 1200 of these deaths were work zone fatalities (Table 1 below). The Insurance Journal[3] reported that there were 43,220 deaths overall on US highways in 2003, up slightly from the 2002 figure, however the U. S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) estimates that the fatality rate in 2003 remained unchanged from the 2002 figure of 1.5 deaths per 100 million vehicle miles traveled.

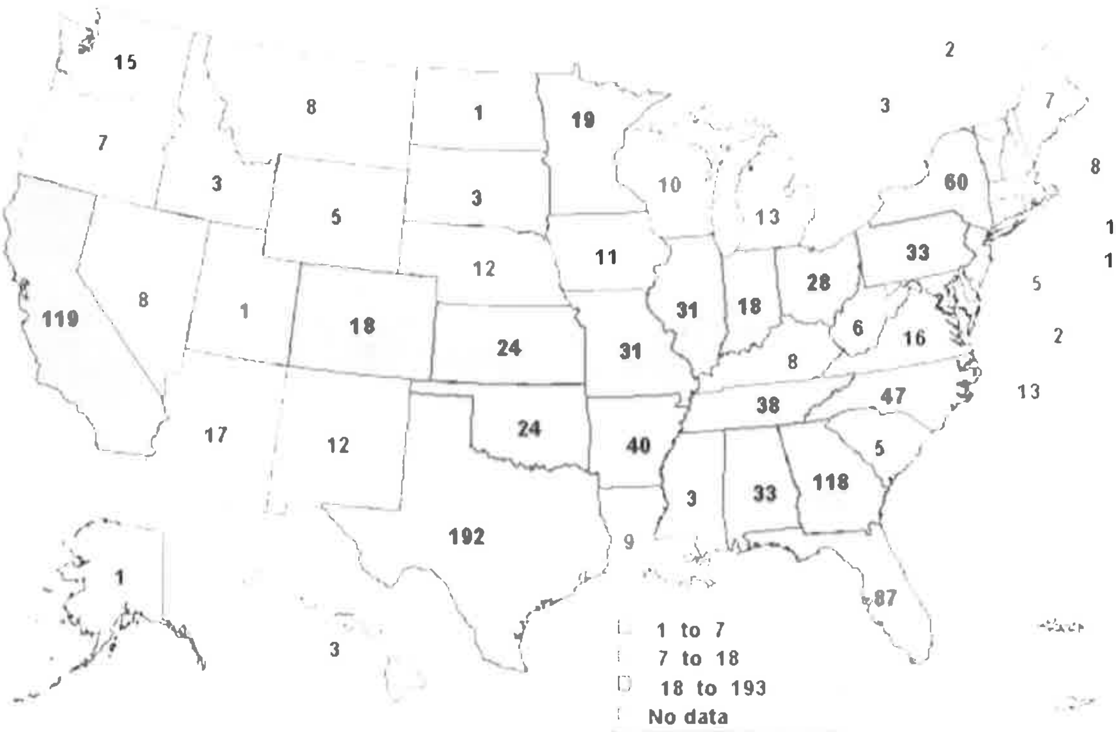
Reducing this toll is a top priority of the US Department of Transportation (USDOT), and the FHWA is advancing a set of strategic objectives and strategies in partnership with other USDOT agencies. Tom Byers, Chairman of the National

[2] Transportation Equity Act for the 21st Century was enacted June 9, 1998. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.
[3] Source http://www.insurancejournal.com/news/national/2004/04/30/41664.htm

Cooperative Highway Research Program's (NCHRP) project 17-18 reported[4] in Washington early 2004 that the nation's target was to reduce the fatality rate to 1.0 per 100 vehicle million miles traveled[5] by 2008 (a saving of over 9000 lives).

Understandably the USDOT priorities are focused on the situations that result in the greatest number of deaths; such as roadway departure crashes, intersection crashes, and pedestrian deaths. While the number of fatal incidents at work zones represents less than 3% of the overall number of deaths on highways in 2002 it represents almost a quarter of the 4970 recorded fatal work-related injuries in private industry for that year. While all fatal workplace injuries are unacceptable the fatality rate for highway workers when set against the overall industry figure is totally reprehensible.

**Number of Work Zone Fatalities - 2002[6]**




[4] Source, Lifelines Volume 1, No.1 March 2004 (http://safety.transportation.org)
[5] The 2003 Washington State Data Book, reported that 54.8 billion vehicles were traveled in US in 2002 (Source: http://www.ofm.wa.gov/databook/transportation/tt02.htm)
[6] Sources are the Fatality Analysis Reporting System - see http://www-fars.nhtsa.dot.gov/, and travel data from FHWA Policy - see http://www.fhwa.dot.gov/policy/ohim/hs02/vm2.htm.) Users are also encouraged to review other key state-by-state indicators such as safety belt use and alcohol-involved fatalities, as maintained by the National Highway Traffic Safety Administration - see http://www.nhtsa.dot.gov/nhtsa/announce/press/2003/seatbelt.pdf for most recent safety belt data, for instance.)

In the 4-year period up to 1997 New York State analyzed 240 incidents involving serious injury to workers on highway and bridge construction projects and reported that traffic accounted for 22% of the injuries and 43% of worker deaths. A significant percentage of the traffic incidents (44 hospitalized and 3 deaths) were as a result of being struck by construction vehicles.

| **Table 1. Highway Fatalities** | **Total all States** | |
|---|---|---|
| **Calendar Year 2002** | **Number** | **Percentage** |
| Total number of highway fatalities | 42,815 | |
| Pedestrian fatalities | 4,808 | 11.2% |
| Work zone fatalities | 1,181 | 2.8% |
| Roadway departure fatalities | 25,241 | 59.0% |
| Intersection fatalities | 9,167 | 21.4% |
| Source: http://safety.fhwa.dot.gov/pubs/stats2002/ (Published January 2004) | | |

The percentage of work zone fatalities when compared to total work-related fatal incidents has risen from 18% to almost 25% in the ten-year period from 1992. In that period the total work related fatalities was on a slow steady decline, falling below 5000 for the first time in 2002. In the same period work zone fatal incident experienced a corresponding rise. The FHWA's "Work Zone Safety Factsheet[7]" put it into perspective as follows; there is one work zone fatality every 7 hours, one work zone injury every 15 minutes and a financial loss of $3bn from work zones crashes [2001]. Clearly some drastic action is needed to reverse the trend.

| **Table 2. Work-related Fatalities – Private Industry (10 year figures)** | | |
|---|---|---|
| **Year** | **Highway Transportation** | **Total work-related fatalities** |
| 1992 | 1012 | 5497 |
| 1993 | 1068 | 5643 |
| 1994 | 1192 | 5959 |
| 1995 | 1150 | 5495 |
| 1996 | 1186 | 5597 |
| 1997 | 1212 | 5616 |
| 1998 | 1260 | 5457 |
| 1999 | 1314 | 5488 |
| 2000 | 1205 | 5347 |
| 2001 | 1222(N) | 5281 (N) |
| 2002 | 1193(P) | 4970 (P) |
| N: Excludes Sept. 11th terrorist attacks, P: Preliminary<br>Source Bureau of Labor Statistics (www.bls.gov) | | |

[7] Source: http://safety.fhwa.dot.gov/wzs/factsheet04.htm

## LEGISLATION – THE INTENT

Highway work zone fatalities occur in every functional highway classification. Work zone situations require increased attention because motorists are often faced with situations outside their expected norm and are required to take special care. The core legal requirement for employers is to provide work places and environments that are free from recognized hazards that cause or are likely to cause death or serious physical harm to employees.

Codes of federal Regulations, the Manual of Urban Traffic Control Devices (MUTCD) and other industry specific guides that provide more specific details on how the fundamental duty may be met in regard to specific work operations supplement the parent law. The basic premise in construction safety legislation is that projects should be capable of being designed, built, maintained and demolished in a manner that does not cause harm to the workers or others who come in contact with them (McAleenan and McAleenan, 2002[8]). For many years now legislators have been intent upon creating the conditions whereby risk in the workplace would be eliminated. In 2000, the UK's Health & Safety Executive issued a discussion document on regulating higher hazards in the workplace. Principal 2 stated,

> "Permissioning regimes require operators to describe how they plan to achieve and maintain control, and to demonstrate active commitment to the effective management of risk. The overall objective is to secure an integrated and coherent approach to eliminating hazards and managing residual risks that would work without the intervention of the safety regulator".[9]

However despite the existence of our present laws, the continuing introduction of new laws, supplementary regulations and guidance workplace accidents continue to occur, seemingly unabated. What those who assess the situation and call for new laws and tighter controls fail to appreciate that it is not the standard of the law that causes accidents in the workplace. The state aims to eliminate workplace hazards and many safety professionals understand that that is the intent behind 'risk management'. The mistaken notion that has grown up around risk management is safety despite the fact that what it really means is to get risk to an acceptable level. This is far from being the intent behind safety and health legislation. If the fundamental legal requirement is to provide safe working environments and products then there is no need for additional laws to control industry. Rather there is a need to reappraise the operation within the context of the working environment, work with what we have and manage it better.

What is called for is a dynamic management model, focussed on elimination of or control of hazards rather than risks that can yield significant results.

[8] Source: "Dynamic Safety Management", paper presented at NSC PDC, San Diego 2002
[9] HSE Books, DDE15

## OPERATIONAL ANALYSIS AND CONTROL (OAC)

An operation managed dynamically is one in which all of the hazards have been considered and the controls have been put in place so that the operation itself is free from risk. In theory the mechanism for controlling the work operation is relevant providing the basic principle "a safe start and a safe outcome" is upheld. The rider here is that certain statutory requirements (e.g. MUTCD) need to be adhered to. If risk continues to exist it can only be because there are insufficient controls. Therefore, by managing the operation, concern can then be focused on the reliability of the control mechanisms rather than the probability of exposure to the hazard itself.[10]

The purpose behind the Operational Analysis and Control model (Figure 1) is to ensure that work operations are carried out in strict accordance with all relevant 'safe working' procedures. In that way people, plant and property are protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced.

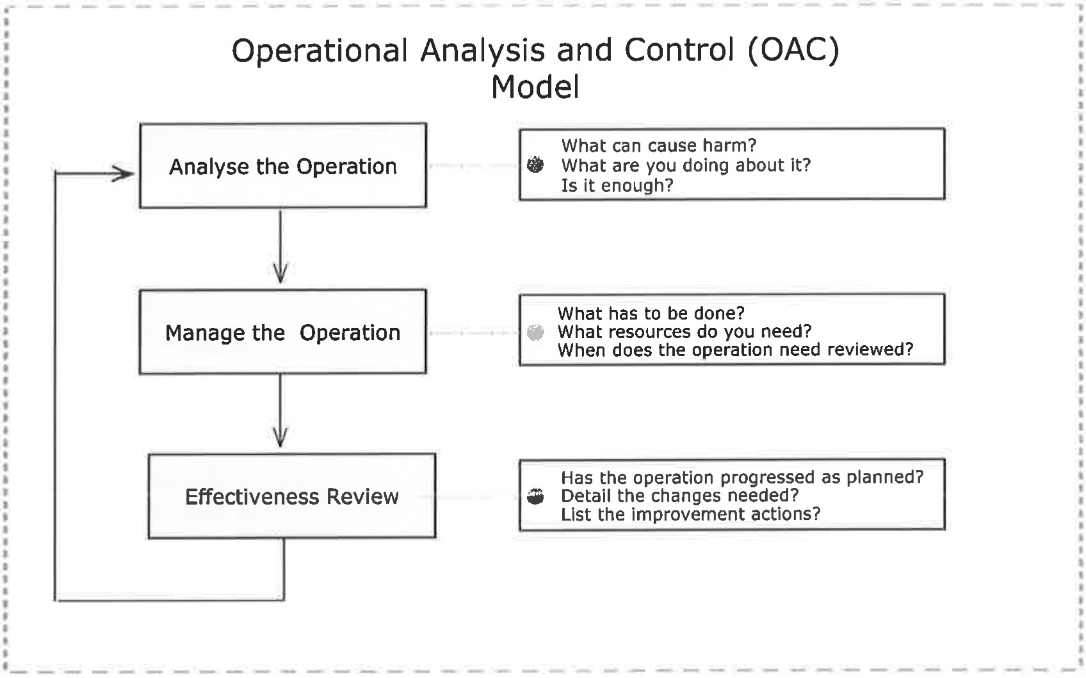



**Figure 1**

The Operational Analysis and Control model does not start with the identification of the hazard, rather it goes to the real starting point; that is the work operation. Many systems start with the hazards and lose sight of what is important because the focus is too narrow. When the objective is 'a safe outcome to a successful

[10] Gerry Ayers, Safety Professional, Australia and participant in ISSA Construction symposium Paris, 2001 in a private correspondence with the presenter, February 2002.

work operation' then it is important to start to look at anything that will prevent that aim from being realised.

Within the highway and street construction industry there are a wide range of work operations and many employees involved in the different work activities associated with each operation. To begin the OAC process requires the compilation of a categorized list of all of these work operations. From that list it is possible to identify the hazards simply by asking, "What can cause harm?" Remember to always think of this in its widest sense;

- What can cause the workers harm? (Road Traffic, Construction Plant and machinery, noise, vibration, substances, radiation etc.)
- What can cause harm to the operation? (Workers/ visitors/ lack of resource etc.)
- What harm can the environment cause to the workers? (Sun, extremes of weather.)
- What harm can be caused to the environment? (Emissions, spillage etc.)

Once you know what can cause harm you can look for the ways to eliminate the hazard (i.e. look for alternative ways of doing the work), contain the hazard (look for ways of isolating the worker from the hazard or isolating the hazard from the worker) or control the hazard (proper management procedures such as safe working procedures, permits to work, training and assessment, use of personal protective equipment, health surveillance, monitoring and auditing). It depends on the nature of the work operation and the skills within a company whether all of this can be done from within. The competence of managers and supervisors will be central, as will the skills of the workforce. Remember those that carry out the work task often have a good idea of what will make the operation safe.

**HIGHWAY and STREET CONSTRUCTION - ANALYSE THE OPERATION**
What can cause harm?

An analysis of highway and street construction operations indicates a wide range of work operations and associated hazards. Many of the hazards are intrinsic to the construction industry and not specific to highway construction activities. While all of these hazards need to be eliminated, contained or controlled and the OAC process is well suited to resolving this (Table 3), the focus here is on the hazard specific to highway and street construction work, namely the interaction between the highway work zone operative and the road user when work is proceeding on or in proximity to the highway.

**Table 3 – Operational Analysis and Control Sheet – Highway and Street Construction**

| Work Operation | Hazard/ Harm | Control | Resources |
|---|---|---|---|
| Use of power tools and equipment. | • Weight and shape<br>• Noise and vibration.<br>• Dust and fume.<br>• Moving parts.<br>• Hot surface.<br>• Substances. | • Manual handling techniques.<br>• Vibration monitoring.<br>• Fire safety plans.<br>• Safety data sheets. | • Mechanical lifting aids.<br>• Ear defenders. |
| Working at heights. | • Height. | • Access equipment<br>• Medically fit. | • Equipment Maintenance regime<br>• Harness & lifeline.<br>• Training in use of equipment. |
| Working on the highway. | • Road traffic<br>• Construction equipment and vehicles. | • Temporary traffic control plans.<br>• Work safety zones (internal traffic control plans)[11]<br>• Impact protection<br>• Incident management<br>• Effective communication | • Temporary traffic control devices.<br>• Signing vehicles.<br>• Vehicle restraint systems<br>• High visibility clothing<br>• Competent workers<br>• Work zone checklist |
| Power lines and utilities | • Buried services.<br>• Overhead power lines. | • Safe digging practices.<br>• Maintain safety clearances | • Cable and pipe locators.<br>• Goalposts |
| Outdoor working | • Inclement weather<br>• Temperature and Humidity<br>• Heat stress | • Working patterns to match weather conditions (e.g. use of shade, rest breaks). | • Protective clothing<br>• Work timetable |
| Laying road pavement materials | • Hazardous materials (e.g. asphalt fume, cement or silica dust)<br>• Weight, shape and maneuverability of material. | • Defined in MSDS | • Equipment defined in MSDS |
| General requirements | • Competent workers, with appropriate training<br>• Medically fit<br>• Protective clothing to suit the operation<br>• MUTCD and work zone checklist | | |
| Note: This table is simplified and incomplete. It is included only as an example to illustrate the OAC process. | | | |

[11] There is a need for clearance between works on highway verges and the edge of the carriageway. The clearance constitutes a safety zone into which persons, equipment, transport and plant should not enter in the normal course of work and in which materials should not be deposited or stored.

In Europe concerns are being expressed regarding the number of road traffic accidents involving highway construction workers. Within the UK and Ireland the unease is such that the major client organisations the contracting industry and the enforcers have got together to steer through innovation in temporary traffic control. This body, "Safer Temporary Traffic Management Operations Initiative" has reviewed and developed guidance, established vehicle specifications for temporary traffic control and will provide a significant input into the development of the new national standards.

Concerns are not confined to Europe. Recent reports from safety professionals in the US indicate that the same level of concern is being raised there. Clearly much work is being done or has been done on both sides of the Atlantic in this field. In 2003 the Federal Highway Administration published a final rule to 23CFR 655.23. CFR 655, which regulates traffic control devices on Federal-aid and other highways[12], prescribes procedures for obtaining basic uniformity of traffic control devices on all streets and highways. The Manual on Uniform Traffic Control Devices (MUTCD) has been approved as the National Standard for the achievement of this purpose.

In the UK a number of industry-specific guidance documents have been produced and published in recent years including good working practice guidance on temporary traffic management and guidance for temporary traffic management[13]. The authorship and ownership of these documents spreads right across industry, covering client, contractor and the enforcement agencies interests. The major document for traffic control advice and guidance, Traffic Signs Manual, Chapter 8, published in 1991 is currently undergoing a major revision.

There is no one temporary traffic management solution that fits all situations, indeed often there are many differing solutions available each with their merits and each presenting a safe working solution. The priority for the person designing temporary traffic management plans is to provide a level of detail appropriate to the complexity of the work project or traffic incident.

**HIGHWAY and STREET CONSTRUCTION - ANALYSE THE OPERATION**
What are you doing about it?

"The control of road users through a temporary traffic control zone shall be an essential part of highway construction, utility work, maintenance operation and incident management. Road user and worker safety should be an integral and high priority element of every highway construction project from planning through design and construction [14]"

[12] Source: http://mutcd.fhwa.dot.gov/res-23cfr655.htm
[13] http://www.highways.gov.uk/aboutus/corp_docs.htm
[14] Extract from Manual on Uniform Traffic Devices

FHWA is actively pursuing improved work zone safety through a multi-faceted approach in the fields of engineering, education, enforcement, and coordination with public safety agencies (police and fire). FHWA also partners with a variety of organizations that are interested in improving roadway safety[15].

It is through the use of best practice guidance such as those produced in the US (MUTCD) and the UK (Chapter 8)[16] that the designer will achieve an acceptable design standard.

## Tools and techniques

### MUTCD

Part VI of the manual on uniform traffic control devices (MUTCD[17]) establishes basic principles and prescribes standards for the design, application, installation, and maintenance of the various types of traffic control devices for highway and street construction, maintenance operation, and utility work. In its opening paragraphs the following is made clear;

> "The primary function of TTC is to provide for the reasonably safe and efficient movement of road users through or around TTC zones while reasonably protecting workers, responders to traffic incidents, and equipment. Of equal importance to the public traveling through the TTC zone is the safety of workers performing the many varied tasks within the workspace. TTC zones present constantly changing conditions that are unexpected by the road user. This creates an even higher degree of vulnerability for the workers and incident management responders on or near the roadway. At the same time, the TTC zone provides for the efficient completion of whatever activity interrupted the normal use of the roadway.
>
> Consideration for road user safety, worker and responder safety, and the efficiency of road user flow is an integral element of every TTC zone, from planning through completion. A concurrent objective of the TTC is the efficient construction and

15 FHWA partner organizations include the American Association of State Highway and Transportation Officials (AASHTO), State Departments of Transportation, the American Traffic Safety Services Association (ATSSA), the American Road and Transportation Builders Association (ARTBA), Texas Transportation Institute (TTI), the Institute of Transportation Engineers (ITE), the National Utility Contractors Association (NUCA), the International Association of Chiefs of Police (IACP), the National Association of County Engineers (NACE), the American Public Works Association (APWA), and the Governors Highway Safety Association (GHSA).

16 Full title "Traffic Signs Manual Chapter 8 – Traffic Safety Measures and Signs for Road Works and Temporary Situations" (Two Volume set)

17 Source: http://mutcd.fhwa.dot.gov/HTM/2003/part6/part6-toc.htm

maintenance of the highway and the efficient resolution of traffic incidents."

FHWA considered that such extensive and comprehensive guidelines, standards, and options in the MUTCD assistance in applying the Manual to unique local settings and circumstances would be very useful. To facilitate this they established the Peer-to-Peer program[18] on Traffic Control Devices (P2P TCD). The program is designed to quickly connect expert volunteers[19] with the professionals who need guidance on technical issues, pertaining to the MUTCD and related technologies.

**Work Zone Best Practices Guidebook**

The Best Practices Guidebook is a vehicle to promote the sharing of practices within the highway community that reduce construction and maintenance impacts on mobility and safety. The practices may be approaches, procedures, or technologies that are "state-of-the-practice" in work zone mobility and safety management. These practices were collected from those observed during a work zone scanning tour of 26 states, and will be added to as other practices are identified and documented by practitioners across the Nation.

**Work Zone Safety Standards and Practices Database[20]**

The Work Zone Safety Standards and Practices database includes 1538 records (with a link to the full text if they are available on the web) of state work zone legislation, standard specifications, special provisions, traffic control plans, MUTCDs, construction manuals, and descriptions of state and other organizations' practices in relation to work zone safety.

**QuickZone[21]**

Work zones account for nearly 24 percent of nonrecurring congestion, which translates to 482 million vehicle hours of delay per year. The four main causes of nonrecurring congestion are crashes, weather, work zones, and breakdowns.

The 1998 FHWA report, "Meeting the Customer's Needs for Mobility and Safety During Construction and Maintenance Operations", recommended developing an easy-to-master analytical tool to quickly and flexibly estimate and quantify work zone delays in all four phases of the project development process (policy, planning, design, and operations). The result was a traffic delay estimation tool

[18] FHWA's P2P TCD provides a way for transportation officials to get answers to their questions about traffic control device issues. The P2P TCD program is easy to use: send an email to P2P@fhwa.dot.gov or call toll-free at 1-888-700-PEER (7337). The Program Coordinator will select a peer from the volunteer database who is able to answer your question and have the peer contact you directly.
[19] Having expertise in specific traffic control devices.
[20] Source: http://wzsafety.tamu.edu/searches/practices.stm
[21] Source: http://mctrans.ce.ufl.edu/featured/QZone/

called QuickZone, which is designed for State and local traffic construction, operations, and construction planning contractors. QuickZone is a traffic impact analysis tool that can be used to estimate work zone delays. For example, QuickZone allows highway and street owners and contractors to compare the effects of doing highway work at night instead of during the day, or of diverting the traffic to different roads at various stages of construction. These effects can be estimated for periods as short as one day or for the entire life of the construction project. QuickZone provides an easy-to-use, easy-to-learn tool that takes advantage of software tools that are familiar to the target user base.

## HIGHWAY and STREET CONSTRUCTION – MANAGE THE OPERATION

## TEMPORARY TRAFFIC CONTROL PLANS

The purpose of traffic control devices is to promote highway safety and efficiency by providing for the orderly movement of all road users. The objective when developing detailed traffic management plans to meet this purpose is to present a practical solution to facilitate the safe passage of traffic past the highway and street construction/ maintenance works and in so doing ensure the safety of the highway work zone operative. As part of the design of the temporary traffic management system the designer must also consider how the system will be safely erected, cleaned and maintained throughout the life of the highway construction project and eventually safely removed.

Signing and guarding of highway work zones must always accurately convey what is expected of road users and where the work safety zones are located. Having said that, temporary traffic control should be designed on the premise that drivers will only reduce their speed if they perceive a need to do so. The selection of the actual method and the operation of setting out and removing temporary traffic controls must be carried out by competent designers and operatives[22]. The particular point of conflict between the worker and the road user is most pronounced at these times, consequently training, competence and access to the correct vehicles and traffic control devices are imperative. Good planning demands that consideration is given to directing traffic away from the highway work zone. This could be though the use of traffic diversion routes although this isn't always practical and can present a different set of hazards, particularly if the only diversion routes available are not sufficient to carry the projected increase in traffic volume. Alternative ways of keeping the traffic away can be achieved through the judicious use lane closure techniques.

[22] Within the UK and the North of Ireland National Highway Sector Schemes are being introduced for temporary traffic management operations (Appendix 1). These Sector Schemes, published by UK Accreditation Service, are partnerships between clients, trade associations, the certification industry and training bodies where appropriate, which are generally built on the requirements in the Specification for Highway Works for contractors to have ISO 9000 certification. The training and competence assessment is a mixture of classroom work and on-the-job assessment. Operatives and their foremen progress through a number of levels while the company is required to have a quality management scheme and all of the correct vehicles and equipment.

The range of issues associated with temporary traffic control planning includes;

- Plan the work to optimise efficiency,
- Provide purpose built traffic management vehicles and keep plant and machinery to a minimum,
- Strive for minimum time and road space for maintenance work,
- Liaise with appropriate authorities such as incident management responders,
- Avoid working during peak traffic flows, where possible,
- Avoid long coned off sections with no visible work activity,
- Monitor and react to traffic flows
- Do not create additional hazards when establishing temporary traffic control,
- Use positive traffic control such as; temporary traffic signals, flagging, shuttle or convoy working and give & take regimes.

Improved road user performance will be achieved where these measures are properly addressed at the outset and will be further enhanced through a well-prepared and well-executed public relations drive. Public relations should cover the nature of the work underway, the timing and duration of its execution, the likely effects on road users and the existence of alternative travel routes. The public relations exercise must stress how vital it is that road users employ extreme caution when passing through temporary traffic controls in order that they do not compromise the safety of the highway construction worker. The Highways Agency in the UK have a safer driving through roadworks website[23] set up to educate the travelling public and in US the FHWA offer the following tips for driving safely in work zones[24];

1. Expect the unexpected,
2. Slow down,
3. Don't tailgate,
4. Keep a safe distance between you and the car ahead of you,
5. Pay attention to the signs,
6. Obey road crew flaggers,
7. Stay alert and minimize distractions,
8. Keep up with traffic flow,
9. Schedule enough time to drive safely and check radio, TV and websites for traffic information, and
10. Be patient and stay calm.

[23] http://www.highways.gov.uk/knowledge/saferdriving/
[24] Source: http://www.fhwa.dot.gov/bridge/prefab/facts.htm

## HIGHWAY and STREET CONSTRUCTION – EFFECTIVENESS REVIEW

Much work has gone into the development of guidance for developing safe working practices and yet there are still high instances of fatalities among highway construction workers.

Driving the safety at highway work zones agenda forward will require competence at organisational and individual operative level alongside the provision of appropriate construction vehicles and traffic control devices. The Department of Health and Human Services[25] in April 2001 published findings from a conference on building safer highway work zones. The participants to the conference, from all parts of US industry and statutory authorities agreed a number of practices that could be pursued by all to ensure continued and improved;

- Safety of all workers on foot around traffic vehicles,
- Safe operation of construction vehicles and equipment in highway work zones,
- Planning for safe operations within work zones, and
- Special safety issues associated with night work in highway construction.

In the UK a trials team has been established under the auspices of the Safer Temporary Traffic Managements Operations Initiative[26] and in the coming months will be examining areas such as;

1. The use of mobile lane closure vehicles to provide a break in traffic flow through a work safety zone. Work in this area is dependant on the further development of the signing and lighting specification and trials are expected soon.
2. Cone laying and retrieval machines. This area has been mooted in the past and has come to the fore again in the UK. There is some work on going with the development of a specification. Cone laying machines tend towards laying cones longitudinally[27], however there are many practitioners in the industry who consider that cone laying machines will only show real benefits when they are able to set out and remove safety tapers.
3. Mobile speed detection. This involves testing the methodology for the application of enforceable speed detection at temporary traffic control sites. Early speed information is being analyzed before extending the trial.

[25] Source: http://www.cdc.gov/niosh/2001128.html
[26] The Safer Temporary Traffic Managements Operations Initiative was set up by the UK highway authorities and comprises client, contractor, the Health and Safety Executive and consultant designers.
[27] The AHMCT Cone Machine can automatically place traffic cones in the forward travel direction and retrieves them in either forward or reverse directions at speeds up to 10 mph. http://www.ahmct.ucdavis.edu/cone/cone_mn.htm

4. Some other areas for the future include consideration of cone taper protection systems, conspicuity of vehicles on the hard shoulder/ edge of carriageway, the use of different colors of signs and the use of "merge in turn" signs.

While acknowledging that these particular trials are UK based they may end up having wider use in the highway construction industry across the world.

In the early 1990s the US Department of Transportation established Technology Transfer Centers related to highway design and maintenance and this included work zone safety. The centers were set up in the civil engineering departments of various universities such as the University of Maryland, College Park campus. The "Mobility and Safety Product Team" formed in April 1999 by the Federal Highway Administration has focused on mobility, safety, and productivity issues associated with construction and maintenance work zones.

Current and future activities pursued by this team will focus on development of products that are responsive to field needs and that directly influence work zone mobility and safety through the coordination of research, sharing of technology, and facilitation of training. One of their products, developed recently, is QuickZone, a Microsoft Excel spreadsheet used to analyze highway corridors. This tool for transport planning professionals and temporary traffic management designers allows a realistic estimation of corridor delay resulting from reduced capacity through highway work zones. The software can also consider alternative work phasing, delay mitigation strategies and work completion incentives. This is one of a planned suite of four products that will make up the Federal Highway Administration's strategic work zone analysis tools.

## Conclusion

Reporting in a recent "Roads and Bridges" publication[28] the editor, Bill Wilson commented, "If a motorist knows what to expect [when approaching a work zone] they'll be able to react and make the right moves". He was speaking in the context of the launch of the Vermont Guide to Highway Work Zones, which includes a checklist and rules and regulations on how to set up and operate a work zone. This approach addresses key issues relating to consistency and competence and it is expected to roll out across other States in the near future.

Much work has been done and clearly much more needs to be done if the highway and street construction industry is to be able to stand up and say that not only is this a good industry to work in but it is a safe one. The spotlight has turned upon the industry and all of the players are rising to the challenge.

[28] Source: http://www.roadsbridges.com/rb/index.cfm?fuseaction=showArticle&articleID=4761&learnMore=yes&CFID=62471&CFTOKEN=34764085

If Goal 19 of the Strategic Highway Safety Plan[29] is to be successful the safety professionals need to push the agenda forward. The industry needs to educate its workers and the travelling public, enforce work zone restrictions and continue to learn and develop best practice. In that way maintenance and construction practices, design standards, and contracting procedures to find ways to reduce the number and duration of work zones will emerge.

The reason the OAC model works so well is that it is an iterative process that you work at it until you have exhausted all of the obvious possibilities then you ask, "Is that it?" The answer that question will always be NO while there are still fatalities and injuries at highway work zones.

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[29] Source for Goal 19: http://safety.transportation.org/elements.aspx?cid=HWS&gid=19 [Strategic Highway Safety Plan].

## Appendix 1 – Traffic Management Sector Scheme (UK)

(Source Lance Williams of UK Government's Highways Agency)

Highway Sector Schemes are partnerships between clients, trade associations, the certification industry and training bodies where appropriate, which are generally built on the requirements in the UK's Specification for Highway Works for contractors to have ISO 9000 certification.

Traffic Management Sector Schemes provide

- An agreed definitive interpretation and understanding of the BS EN ISO 9000 series of standards for identified activities and product supply.
- An industry benchmark for performance, workmanship and minimum levels of training and competency for operatives (and management)
- A basis for continuous improvement through feedback and other methods
- A focus on quality
- Ownership of the scheme through a partnership framework
- A robust, transparent quality management system
- A forum for industry to discuss and exchange information and views on quality, environment, specification and other issues
- A benchmark of competency and skill for auditors employed by "accepted" Certification Bodies.

The scheme has its own national technical advisory committee, drawn from relevant trade associations, clients, training organizations and certification bodies. The committee establishes the criteria needed for its industry and identifies gaps that need to be improved.

The Temporary Traffic Management (TTM) industry was advised in the late 80s that they should consider putting their house in order by adopting BS 5750 [forerunner to ISO9000] including training for their staff. By the mid 90s the industry had sufficiently organized itself, that it was possible for the HA to require TTM to operate QMS. The first issue of sector scheme 12A (TTM on high speed roads) was introduced in July 1998

### Training of the workforce

Although the industry had developed a reasonable training program, the committee believed that a third party should administer it and interest in the program was sought through competitive tendering. The successful independent body brought in robust systems of verification and registration for operatives, foremen, trainers and subsequently assessors to ensure that standards would be maintained.

As part of this process a standing sub-committee was set up to review training and competency requirements, membership was drawn from members of the main committee plus invited organizations including HSE. The committee meets regularly to review new developments and has already produced a course, program and syllabus for IPVs

Training and assessment is carried out in 3 phases

- off the job training module for TM operatives
- on the job assessment for TM operatives
- off the job training module for 12A TM foremen or
- off the job training module for 12B Lead TM operatives (LTMO)

The 12A foreman automatically qualifies as a LMTO.

Training is provided on a progressive basis for operatives and foremen. Candidates must successfully complete the Operatives Basic Day Module before progressing further.

Before the candidate is registered as a traffic management operative she/he must have successfully undergone the one-day training module and have been successfully assessed for competency by an approved assessor.

As part of the assessment process the candidate must, before submitting to final assessment, maintain and complete an official logbook. Copies may be obtained from Lantra Awards.

Candidates applying for the off the job training module for foremen/LMTOs should be registered traffic management operatives. On successful completion of the course, the candidate will be entitled to have his/her registration upgraded to foreman/LMTO category.

TM Registration Cards are issued to TM operatives who successfully complete an approved training and assessment programme. The TM Registration Card will define the type of traffic management the holder has been trained and assessed to undertake and the degree of responsibility that the holder can normally accept. It shall not be valid for any type of TM that is not defined. The card will be valid for a period of 5 years (inclusive of a 6 month renewal period).

The schemes put limitation on the number of men a foreman/LMTO manages and the ratio of unregistered operatives to registered TM operatives.

Foremen may control up to 5 operatives

LMTO may control up to 3 operatives

Unregistered TM Operatives (trainees) are to be supervised by a trained registered TM Operative on a one to one basis.

Unregistered TM operatives shall attend relevant TM training within 6 months of starting employment. However, there shall be no more than one unregistered operative to every three registered operatives when the gang has four or more members. When the gang is smaller than this there shall be no more than one unregistered operative in the gang.

Lastly, a traffic management company shall maintain a minimum complement of 8 registered traffic management operatives to meet the requirements of this scheme.

It should be noted that although the committee believes that the training and VQ syllabuses provide up to date information and advice on best practice and health and safety issues, the training and assessment of operatives required by this Scheme is aimed primarily at technical competence for traffic management. It is intended to provide awareness to carry out work in a safe manner however it remains the responsibility of the Organization to determine and implement safe systems of work.

## Core Principle

Engineers and designers must design construction projects that can be built, used, maintained and eventually demolished in a manner that does not cause harm to construction personnel, end users, maintenance operatives, demolition specialists, and others who may come into contact with the project. On the interface between client, designer, engineer and contractor this requires the acceptance of project objectives that include tasks/ activities being completed on time and in a manner that does not cause harm to the employees, customers, other non-employees, or the company.

Some hazards can be eliminated or contained through good engineering design solutions and others, inherent in the process, have to be worked around. In all cases it is essential to identify at the earliest opportunity what hazards exist, the harm that can result and how it does so.

Fundamentally this necessitates a full analysis of the design safety issues and the development of appropriate controls to ensure that work operations during the construction phase proceed in a manner that make certain that people, plant and property are protected from harm prior to, during and after the work operation, regardless of the nature of the hazards faced.

The design safety analysis and control process (below), derived from the OAC model integrates all aspects of the project process including those associated with the design elements in construction. Underpinning this approach to safety is the elimination of risk through the absolute control of all stages of the process.

The model suits the requirements of European Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites with particular reference to project preparation.

There are three stages to the design analysis and control model as follows

## Stage 1 –Analyse the Design

Hazard identification must commence when the project is first proposed. The ideas of the client, the location chosen (if already done so) and the financial resources that he makes available represent the beginning of the process and all of the parameters set at this point impact upon the construction and whole life safety of the project. A preliminary assessment of client requirements against project resources at this stage will identify any hazards that may render the project not viable or that need to be adjusted in order to make the project feasible.

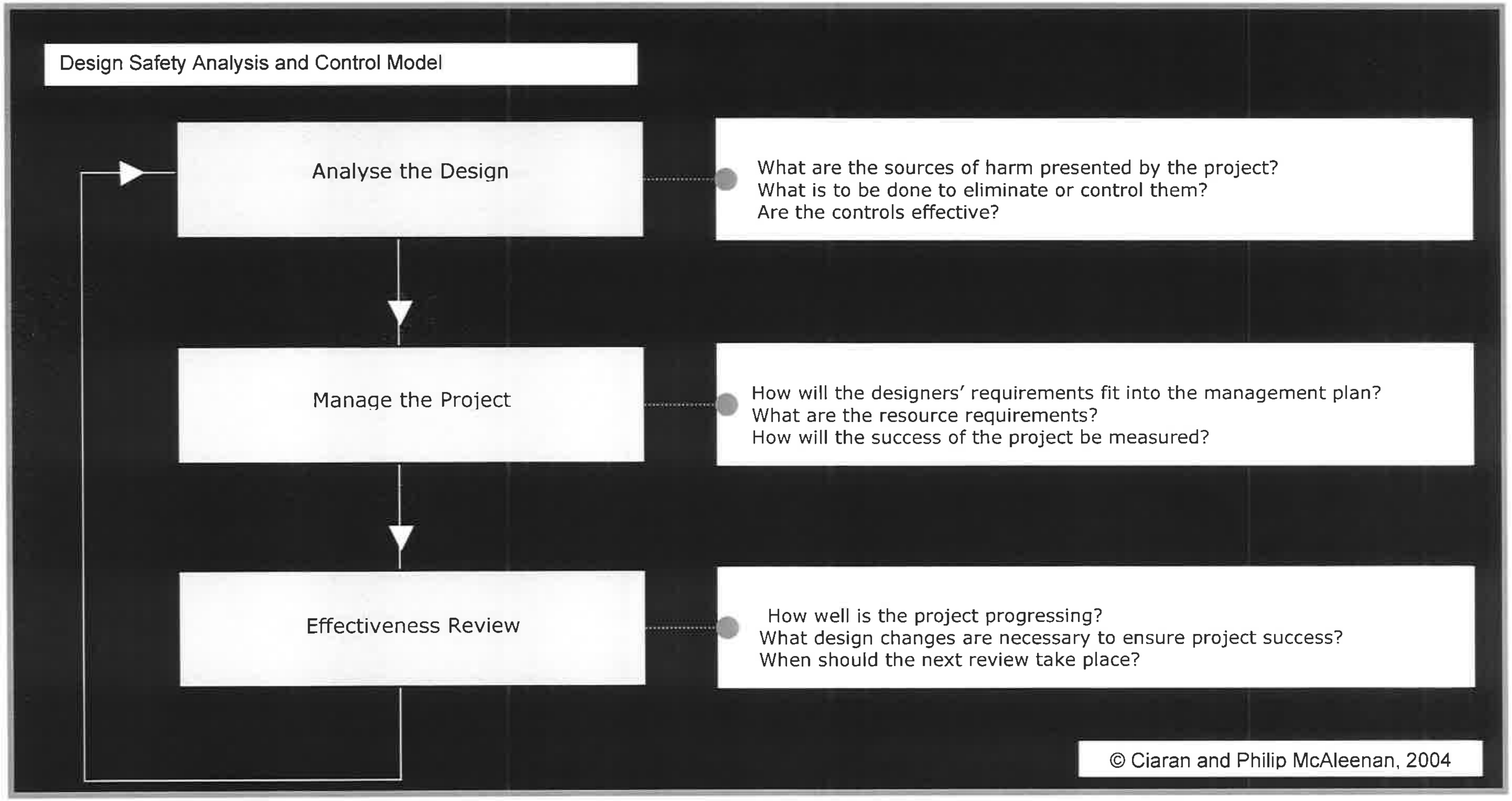



**Figure 1: Design Safety Analysis and Control (DSAC) Model** [1]

[1] The Singapore inquiry has recommended that 18 similar on-going projects undergo a comprehensive engineering review of the design and safety measures (NCE 23 September 2004, p.6)

It is the designers' and the engineers' tasks to identify what hazards are presented by the design, the location, the environment and the materials to be used for any factors in the design that can cause harm. As the project develops and the design is modified, other factors become relevant such as methods of construction, the workforce, the plant and the equipment.

In each of the different phases in the building's life, from construction, to occupation/maintenance and finally to the demolition phase, there are hazards with the potential for harm. Good design principles apply at all stages from the initial building design to the design and erection of scaffolding by contracted in firms.

Critically the process of assessing what hazards exist is not concerned with reducing the risk posed by them rather it is focused on the elimination of the risk through robust and appropriate control systems. Having identified the sources of harm presented by the project design the key players must consider what has to be done at each stage of the project to prevent harm occurring.

Since elimination is the first objective it may be necessary to go back and review the designs. If the hazard cannot be eliminated, then consideration is to be given to all the available alternative control measures necessary to prevent the harm from being realized. Whatever measures are selected they must be sufficient to eliminate or control the hazards described.

Table 1 below illustrates examples of the hazards and design solutions that may be appropriate.

At the design stage, and before embarking on the work operation, it is important to consider whether enough has been done to prevent harm.

There are limitations to the knowledge of any one individual and it is imperative that specialist advice and where necessary crosschecking is sought. Sources of specialist advice include the project coordinator, other designers and architects, contractors, manufacturers and suppliers of materials, plant and equipment, OSHA, trade or professional associations or other safety professionals. In this way the designer and the client can be assured that national and/ or international design standards are being applied.

**UK Roads and Bridges**

The Design Manual for Roads and Bridges, used throughout the UK, includes the provision for a technical approval process.

This process requires independent engineering checks that all standards have been applied. These checks include buildability, constructability and safety.

**Table 2 – Sample Designers Checklist** (Apply appropriate National or International Standards)

| **Phase** | **Hazards / Harm** | **Design Solution** (Note whether it eliminates, contains or controls the hazard) | **Information required for** construction safety plan and/or client safety file[2] |
|---|---|---|---|
| **Construction** | • Bridge construction, working at heights | • Pre-assemble spans and raise to position (eliminates a substantial amount of work at heights) | • Construction safety plan |
| **Occupation & maintenance** | • Painting exposed steelwork (e.g. bridges). | • Use weathering steel (eliminates need for painting). | • Construction safety plan. |
| | • Pipe and cable maintenance or replacement. | • Lay pipes and cables along accessible routes (eliminates need for heights). | • Construction safety plan and client safety file. |
| | • Fragile roof | • Construct and mark permanent walkways, erection of barriers, warning signs (contains) | • Construction safety plan and client safety file. |
| **Demolition** | • Pre-stressed concrete supports | • | • Construction safety plan and demolition sequence in the client safety file |

Note: This table is simplified, incomplete and is included as an example to illustrate the DSAC process

[2] Construction Safety Plans are dynamic documents that describe the measures necessary for ensuring safety at all stages of construction. Client Safety Files are files developed throughout the life of the project and presented to the client/ owner at the end of the construction phase. They are intended for client use during the occupation, maintenance and demolition phases of the project.

Things can go wrong and it important to try and anticipate what they may be as early as possible. Designers in determining whether the controls they have established are effective must ask themselves;

- What could go wrong?
- How could it happen?
- Will the controls be sufficient to prevent harm if things do go wrong?

Asking the questions at the outset focuses the mind and ensures that all the foreseeable incidents have been considered and planned for at the project preparation stage. These questions also prompt consideration of emergency preparedness plans that should be in place prior to starting any particular operation.

**Stage 2 – Manage the Project**

Having carried out the design safety analysis a list of what has to be done to ensure a safe outcome to the construction, use, maintenance and demolition of the building must be drawn up. For example;

- How are the designers' requirements to be integrated into the project management plan?
- Has the client, the project coordinator and contractors been made aware of what can cause harm and what they must do?
- What resources are needed? (Material, technical, human, financial).
- Is it known what specialist skills are needed during the different phases in the life of the building?
- Does everyone know who is responsible and for what?
- How will the success of the project be measured?
- Are the occupational safety and health objectives clearly identified and measurable?

It is important that the resources, once identified are made available. To be effective the controls and the resources necessary for their implementation must be built into the budget and business plan.

It is worth considering some of the issues here.

**Material and Technological**

Some resources will be needed well in advance of any work operation. Others will need to be ordered well in advance of them being needed, for example, custom designed tunnel boring equipment that may take a year and more to be designed, manufactured and tested before delivery to the construction site.

All materials, plant and equipment that are to be used in the construction or the occupation phases must be selected and acquired with care. They must be suitable for their intended purpose, meet any applicable national or international standards and be safe in their normal use.

**Human**

Human resources in any project, from the appointment of the initial designer to the employment of site labourers, must be engaged on the basis of their competence (or agreement to undertake appropriate training) to do their job.

The term "Competent Person" is used in many national standards and documents. As a general rule, the term is not specifically defined, though in a broad sense, a competent person is an individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions. Some standards add additional specific requirements that must be met by the competent person.

Knowledgeable and authorized to act are the key components of competence, and there is no doubt that these are important indicators to a person's likely competence, but as a definition of competence they are inadequate, and as a measure, not sufficient in themselves. A more appropriate definition of competence (at whatever level that may be within the company) would be "*the consistent skilful application of skills and knowledge to any specified work operation*", were the use of the term skilful implies conducting the operation to the highest standards within the field.

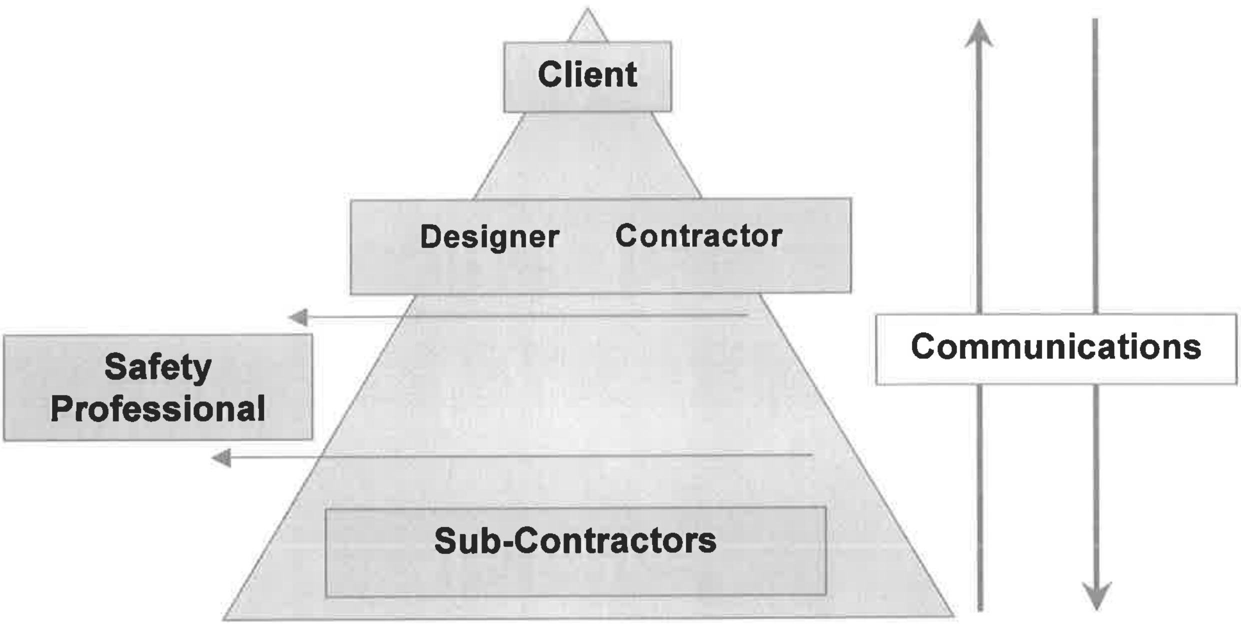
In this respect a competent designer is one who consistently produces structural designs that can be built, used, maintained and demolished without causing harm (in its widest sense) or hurt to construction workers, maintenance workers and end users. Integral to this concept of competence is the notion that, having regard to the designer's age, experience and skill they will know of the hazards and apply the controls necessarily associated with the work.[3]

Importantly, the thread of competence extends throughout a company; executives, managers, supervisors and subordinates with each level skillfully applying their knowledge and skills to the successful completion of their particular work areas (Figure 3, below). Ultimately, in the design process, competence begins with the client who must ensure, through reasonable enquiry and by seeking advice, that the designers and engineers he engages are themselves competent to assess his project and to advise him accordingly on the health and safety issues. The client must also be assured the people he engages are well enough resourced to undertake the duties he requires of them, that they can demonstrate a successful track record in similar work and that they can and will act in compliance with their legal duties for health and safety.

[3] See Dalton v Frendo (1977), Irish Supreme Court.

Where it is necessary and appropriate to do so, a competent professional may be engaged to advise on aspects of health and safety in the construction of the project[4]. Sometimes referred to as a planning/ project supervisor[5] or safety and health coordinator the task is to ensure that all the safety issues have been considered and adequately dealt with by the managers and supervisors at each level. Competent engineers/ designers are well placed to fulfill the safety and health coordinator's role, given the requirements for experience, knowledge and qualifications. It may be that on occasions input from a particular specialist safety professional(s) is called for to assist with the design safety analysis and control process. However a clear delineation must be made between the safety professional's role as an advisor and the project managers' responsibilities to manage safety and ensure that they and their subordinates are compliant.

**Figure 2: Relationships Model**




[4] It is important that professionals engaged to advise on aspects of construction safety and health have a sound working knowledge of safety and health in construction work, a thorough knowledge of the design process and experience of the site processes likely to be involved in the project and in future maintenance, refurbishment or demolition.
[5] EU Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at mobile construction sites refers to the requirement to appoint coordinators for safety and health matters and specifies duties to be complied with at the project preparation [design] stage and the project execution [construction] stage.

Safety of the project commences at the strategic level and develops throughout the design process to the specific safety and health plan implemented at all levels.

Each player in the process has clear roles and responsibilities. The relationship between client, designers and engineers and contractors is a cyclical one where the exchange of information and advice between one party and the next is crucial to the development of the safety plan and the successful outcome of the project. In respect of safety their roles can be summarised as follows;

Thus the process of identifying and selecting on the basis of task requirements and competence applies throughout the project whether selecting designers and engineers, or contractors and employees. It applies to all parties in the process and requires a sufficient degree of managerial competence itself to make it successful. Anything less will introduce hazards to the project and the further along the process it occurs the greater the likelihood and degree of harm caused to the project.

**Stage 3 – Effectiveness Review**

Designs need to be reviewed since believing that a design is safe is a sure way of ensuring that it is not. Designs, like workplace safety measures need to be assessed, managed and improved, as necessary. It is important therefore that time is set for reviewing the effectiveness of the designed safety controls. A review could be triggered;

- When new processes or new equipment are introduced to the operation.
- When new techniques have been developed.
- When statutory obligations require it.
- When resources inputs are set to change.
- When an accident or incident occurs.
- When the site is handed over.
- When maintenance, renovation, demolition is planned.
- At regular intervals (determined by the nature and complexity of the hazards present).

Note: The above list is not exhaustive. An effectiveness review should be carried out at any other time, if it is warranted.

Potentially there are many design issues involved in each phase of the life of the building. The designer of the project has a responsibility to consider how these design issues will evolve after the client assumes ownership. It is important to ensure that these progress as planned, and here a project coordinator plays a vital role. Designs change, as does the use of the building. Designers and engineers need to be aware of the effects of any change and try to anticipate how they will need to be dealt with. Consider the following questions;

- How well is the project progressing, when measured against the projects safety objectives?
- What design changes are needed to ensure project success?
- What effect will they have on the project (timing and/ or resources)?
- How will they be dealt with?
- When should the next review take place?

If nothing has changed then it may be sufficient to note that the review has taken place and set the next review date. If design changes are necessary, they should be itemized in the designer's checklist (see Table 2 above) and consideration given to what information needs to be added to the safety plan and the safety file.

Following an effectiveness review any improvement actions should be listed, an action plan developed, resource implications identified, persons responsible for completing the actions nominated and the timescales for completion drawn up.

Remember that the effectiveness review process is the starting point for learning transfer. Solutions developed in one design are normally capable of transfer to new designs for other projects, either with or without modification. The concept of foreseeability is an intellectual skill in the direct application of or deduction from knowledge from prior design or construction experiences to future situations. If we can draw on past experiences on what can go wrong, likewise we should be equally adept at drawing on past successes in preventing injury and harm.

**Summary**

The design safety analysis and control process is concerned with the identification of hazards in construction projects and the development of sufficient control measures that will ensure that no harm comes to anyone effected by the project, whether employee, end user or member of the public. It is within the gift of the talented engineer to inject enthusiasm for safety and health issues into the design and throughout the whole life of the project. Recognition that hazards exist is the commencement point. What has to be achieved is the identification of the harm that can result and to develop effective controls to prevent that harm from being realized. These controls constitute the safety barrier between the hazards and the construction operator or end-user.

This barrier is the development and use of a variety of suitable and sufficient mechanisms that may include one or more of the following;

- Eliminate the hazard
- Reduce the hazard impact potential
- Control and residual hazards by alternative means
- Information to operators and Safe Working Procedures

The outputs of the DSAC process are a Designers Checklist and an effective health and safety plan that ensure a safe and healthful work environment. The core and guiding principle is that engineers and designers must design construction projects that can be built, used, maintained and eventually demolished in a manner that does not cause harm.

Engineering is the art of the possible and this is just good engineering practice, after all.

By

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24 November 2004

## Title

*Prevention – A Universal Responsibility*

## Session #

September 20, 2005, 11:00 - 12:30

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## Prevention - A Universal Responsibility

### Abstract:

Effective leadership reflects the organisations values and beliefs in a way that faces up to and deals with internal and external pressures. Organisations that are good at managing OSH create an authoritative, multi-directional, leadership structure to maximise the contribution of competent individuals and groups in the delivery of successful prevention and loss control programs.

"Prevention" derives from both the common law and statutory duties of care that, in the specific relationships we establish, we are obligated to act in a manner that will not cause harm to others, whether by design or through negligence. The courts and the legislature have defined and interpreted what those duties and concomitant responsibilities are. This paper makes the case that the simple commandment, "thou shalt not harm..." imposes specific responsibilities on everyone involved in work relationships where others are affected by their actions.

In particular it will be argued that "Prevention" is a universal responsibility to be competently exercised by different partners in the stakeholder framework; statutory, company, contractor and supplier. With reference to the Operational Analysis and Control methodology this paper will further demonstrate that this universal responsibility can be exercised effectively within the matrix of authority extant in any given company, contingent upon authority being addressed as an essential constituent of responsibility.

Finally the authors will present the evidence of how the application of a dynamic approach to operational analysis and control involving client-supplier relationships has engendered effective leadership and management resulting in enhanced prevention strategies.

## Background

The principle that prevention is a universal responsibility is predicated on the concept that competent organisations with the appropriate resources and authority have the technological and intellectual capability to deliver a safe and healthful product or service. Why then do an estimated 2 million men and women die annually as a result of occupational accidents and work-related disease. Across the globe, there are some 270 million occupational accidents and 160 million work related diseases each year. The International Labour Organisation (2005) contends that it has never accepted the notion that injury and disease "go with the job", arguing that prevention works, citing;

> "In the course of the 20th Century, industrialised countries saw a clear decrease in serious injuries, not least because of real advances in making the workplace safety and healthier. The challenge is to extend the benefits of this experience to the whole working world".

Facts on Safe Work, ILO 2004[1]

Acknowledging that prevention works is not proof that it is a universal responsibility, therefore it necessary to examine the relevant key industrial drivers more closely. McAleenan and McAleenan (2002)[2] argue, "that effective operational management necessarily requires the core participants in the production process; worker, contractor, client and legislature to adopt a perspective that acknowledges and acts upon the duties and obligations each owes to the others. These obligations extend to the participant's need to be fully cognisant of the operation and competent in the exercise of their particular role". In essence the competent execution of a project or work activity relies upon the team having collective and individual competence that incorporates resources and authority, consistent with the nature and scope of the activity. The measure of the true and correct inputs to the project relies

[1] See also Report iv, Promotional framework for occupational safety and health, ILO 93rd session, 2005.
[2] McAleenan & McAleenan, "A Different Approach – Operational Analysis and Control", NSC 2002

upon full knowledge of and acceptance that in its execution the organisation or any of its agents will not cause harm to anyone who come into to contact with the product or service. In other words the organisation owes a duty of care to ensure that they are proactive in the prevention of harm.

Operational analysis and control advocates that a work operation or activity must be safe before it starts, offering a mechanism for employers and employees to ensure that they consistently achieve their 'duty of care' obligations. In a critique of the operational analysis and control approach one responder to the NSC 2002 paper replied;

> "Safety doesn't require "duties and obligations". It just requires that where there's a hole in the floor, you don't step in it. "Roles and responsibilities" are written into ES&H Manuals to protect management from plaintiff's attorneys, not to protect anybody from hazards in the workplace… Why would you think anybody is "obligated" to be either cognizant or competent?"

Not withstanding the world-weary cynicism that is evident in this response there are two issues that arise namely;

- The historical duty of care that is owed to our neighbours, and that,
- That duty requires everyone to act in a competent manner in business and in their working relationships.

## Duty of Care Examined

Duty of care derives from the common law obligation to act towards another in a manner that is reasonable in all circumstances, so as to avoid injury to him or his property. It requires that there is a sufficiently proximate relationship between the parties such that obligates them to behave towards each other in way that will not lead to loss or injury either through a reckless act, an unintentionally careless act or an omission[3]. There is a long established history of the courts upholding the duty of care principle[4] and in the modern world the duty is often incorporated into contracts and statutes, which define the nature of the relationship between parties, e.g. employers/ employees, client/ contractor, the specifics of any duty owed by one to the other and the remedies that may be sought for breaching the duty. Nevertheless, the general duty of care, as outlined, continues to exist through the nature of the relationship between the parties, regardless of any contractual obligations.

In this regard it may be argued that statute law, from the primary legislation through its supporting regulations and codes of practice add substance to (make specific) the fundamental duties and rights necessary for the proper functioning of social relationships. Statute law and the courts interpretations, although often the final arbiter, do not present the final word. The qualification of Duty of Care by the legislatures of many States is indicative of the universality of the principle.

For those countries that are party to the intergovernmental OECD the development of and adherence to the corporate governance principles will ensure that the interests and rights of stakeholders are taken into account and respected by the Boards of corporate bodies[5]. The principle is further made manifest through the UN wherein the International Labour Office promotes social justice and internationally recognised human and labour rights in a tripartite structure that involves employers, employees and governments through the development of standards and conventions applicable to the world of work. With 178 member countries[6], there is little doubt as to the universality of the principle and the advent of Decent Work Agenda[7] (2002),

[3] In the UK the authority for duty of care is the leading Scottish case of *Donoghue v Stevenson 1932 SC (HL) 31*
[4] "Duty" was first put forward as a unifying concept in the law of tort in Buller's Nisi Prius published in 1768.
[5] Organisation for Economic Co-operation and Development, Principles of Corporate Governance. The Principles were endorsed by Ministers at the OECD Council meeting at Ministerial level on 26-27 May 1999, last revised 2004. The OECD has 30 member countries including, Ireland, UK, USA. Japan, Korea, Canada, Australia, NZ, Mexico and 20 other European countries.
[6] The level of participation from the member countries will determine the success of the prevention principle
[7] Decent Work – Safe Work, Introductory report to XVI World Congress on Safety & Health at Work, 2002

which advocates the necessity for safe work guarantees that the prevention is an international (if not yet a universal) responsibility.

Remember an understanding or awareness of the universality of the principle of duty of care does not automatically translate into knowledge of how we are obliged to act. The issue often only arises when there has been a failure of that duty and individuals or organisations are faced with defending their actions.

### Concept of Reasonableness

Where duties are made manifest in statute and contract, the issues are very clear; "what we must do is often prescribed by these statutes and therefore the test of failure, is simplified in proceedings". Did I fail to do something that was specifically prescribed? If yes, then I have breached a statutory duty, if no, then I have not". Furthermore was the act or omission such that it would constitute a gross breach of duty[8]?

However in the generality of the principle above and beyond specific statutes, the issue appears much less clear. The duty of care principle does not prescribe or prohibit any specific actions or behaviours, but requires that we exercise reasonable care in our relationships with others so as not to negligently bring about any foreseeable harm or injury.

It has been argued that this is all to encompassing to have any sensible meaning in the real world or that as an historical accident the duty of care principle is superfluous as cases may well be decided on other grounds that do not depend upon a duty at all[9]. The argument goes that statute law has been developed and has quantified what the principle means, which

[8] In the UK's proposed corporate manslaughter legislation (2005) 'Gross breach' would occur when the failure falls far below what can be reasonably expected and the test for that would include; senior managers knew (or should have known) that they were failing, to comply with legislation and guidance, senior managers were aware (or ought to have been) of the risk of death or serious harm posed by the failure to comply, senior managers sought to cause the organisation to profit from the failure.
[9] Percy Winfield, The History of Negligence in the Law of Torts (1926)

effectively limits the duty to practical considerations. Yet the principle is neither embedded in some insubstantial realm of academic intellectualism nor is it one that leads to impracticable or unworkable situations. The courts have had a long time to assess and pronounce on the different elements of the principle and have come up with clear interpretations that ensure that the principle is not only workable, but is in many ways stronger than the statutory interpretations that have been developed to make it manifest.

- Negligence is the failure to take reasonable care to avoid acts or omissions that you can reasonably foresee would be likely to injure your neighbour.

- Foreseeability is the faculty to contemplate the consequences of an act or omission that results from a reasonable standard of competence on the part of the actor [10].

- Reasonable in the circumstances of the particular case is that which is required from an average and prudent person who is guided by considerations that ordinarily regulate the conduct of human affairs[11].

When we apply this to the world of work where does that take us?

With respect to risk assessment (a prevention strategy tool), practised in many countries, the concept of "reasonable foreseeability" has been well established since the 1970s, when many of the principal occupational safety and health (OSH) Acts came into force.[12] However, an important yet little publicised court decision by the Irish Supreme Court in 1977 introduced an

[10] *Donoghue v Stevenson 1932 SC (HL) 31, Blyth v. Birmingham Waterworks Co (1856) LR 11 Ex. at p.784, Hall v. Brooklands Autoracing Club (1933) 1 KB at. P.224*
[11] per. Alderson B., *Blyth v Birmingham Waterworks Co.* (1856) LR 11 Ex. at p. 784
[12] **USA**, Occupational Safety and Health Act of 1970. **UK**, Health and Safety at Work etc Act 1974. **Canada**, Canada Labour Code Part II. **Australia**, National Occupational Health and Safety Commission Act 1985. **South Africa**, Occupational Health and Safety Act (OHSA), 1993. **India**, The Dock Workers (Safety, Health and Welfare) Bill, 1985.

enlightened understanding of what duty of care means when applied to the work situation, thus further strengthening the case for a universal principle of prevention. In the case of Dalton v Frendo[13], it was held that having due regard to the age, skill and experience of a worker, he or she will know the hazards associated with their work and be able to apply the controls necessary to prevent harm. In other words, competence entails the ability to carry out work in a safe manner.

## Concept of Competence

Regulations in many different States carry specific definitions of competence in respect of particular occupations or work operations to which the State regulations apply. These are often couched in terms of the training required by the operation and sometimes in terms of the amount of experience as well. The debate about what is competence and how it can be defined is wide ranging and judging by the various OSH discussion forums on the internet it continues to be an ongoing one. Frequently the debate centres on what particular qualifications are relevant and how much of a particular experience operators and their managers[14] require. Strangely, OSH training is often couched in such a way that it is an add-on (albeit essential) to core training or education, rather than an integral aspect of the core training. Whereas in reality OSH is an integral element in job competencies and therefore the OSH training and education should be integrated into competence based programs for each particular job. This point was presented to the consultation on a UK qualification strategy for OSH[15].

There can be no doubt that individual competence is essential when deciding who to employ or engage (workers, managers or directors). What Dalton did

[13] See Dalton v Frendo (1977), Irish Supreme Court
[14] The term manager is used to hear to refer to anyone in the management chain from Board members through to first line management/ supervisors.
[15] McAleenan, C (2005), acting as corresponding member of the Institution of Civil Engineers Health and Safety Board, presented a paper to the Employment National Training Organisation, who are developing a UK qualification strategy for OSH.

was negate the dichotomy between core training for the job and safety ensuring that decisions on competence, of necessity, mean safe to function. In applying the Irish Supreme Court judgement it is possible to come up with a definition of competence that should effectively lay to rest the debate on what it means. The definition focuses on what is fundamentally required of a competent person rather than on the type of qualification or number of years experience that are in essence elements by which competence may be measured.

A more appropriate definition of competence would be "*the consistent skilful application of skills and knowledge to any specified work operation* (at whatever level that may be within the company)", where the use of the term skilful implies conducting the operation to the highest standards within the field[16]. Here there is no dichotomy between the skills required to do a job and occupational safety and health.

## Compliance in the Matrix of Authority

Within the competency definition there is an inference that the competent person has the resources necessary to act and the authority to decide appropriate actions. Without either the resources or the relevant powers of authority competence is negated and consequently the person is in the position where a breach of his duty of care becomes a distinct possibility.

McAleenan & McAleenan (2000)[17] noted nine factors that contribute significantly to accidents and compliance failures;

1. Deliberate violations
2. Contracting out hazardous work with the intention of keeping the company's recordable injury record down.

[16] McAleenan & McAleenan, Safety in Design – A Risk Assessment Approach, NSC, 2004
[17] McAleenan & McAleenan, Confined Spaces Certification and Licensing Program, ASSE 2000

3. Lack of competence of workforce (includes authority and resources)
4. Inadequate training and supervision.
5. Enforcement or standards shadowing.
6. Variation in standards across states.
7. Cost of training.
8. Quality failures.
9. Unauthorised activities [18].

A close study of the various causes show that it is not simply those that specifically highlight lack of competence or training, which illustrate poor prevention strategies, but even matters such as deliberate violations or work being inappropriately contracted-out are, in the final analysis, examples of failures to act with competence. Competence, as a concomitant to the duty of care, is a universal responsibility that must be exercised by all parties within the stakeholder framework, from the Board via the management team to production operatives, and between Government, private companies, contractors and suppliers[19]. Indeed in the draft Corporate Manslaughter Bill[20] presented in the UK Parliament, March 2005, Home Office Minister, Charles Clarke proposed that;

> *"A "relevant duty of care" in relation to an organisation, means a duty owed under the law of negligence by the organisation –*
> *(a) to its employees as such,*
> *(b) in its capacity as occupier of land, or*
> *(c) in connection with –*
> *i. the supply by the organisation of goods or services (whether for consideration or not), or*
> *ii. the carrying on by the organisation of any other activity on a commercial basis, …"*

The proper exercise of responsibility requires that all within the matrix of work not only hold the competences appropriate to their own post but give respect

[18] Tyson, Patrick R. A Different Era, Safety & Health, November 1999. Atkinson, William, Risky Business, Safety & Health, August 1999
[19] OECD Principles of Corporate Governance, 2004
[20] http://www.homeoffice.gov.uk/docs4/con_corp_mans.html

and due consideration to the competences and requirements of others within the matrix. This idea is inherent in the concepts developed by the International Labour Conference;

> "A national preventative safety and health culture is one which the right to a safe and healthy working environment is respected at all levels, where governments, employers and workers actively participate in securing a safe and healthy working environment through a system of defined rights, responsibilities and duties, and where the principle of prevention is accorded the highest priority".[21]

In practice this means that everyone comes to his or her respective position or job competent to function in that role. Those with management and directorial responsibilities ensure that the people they manage are provided with adequate resources to carry out their jobs and have been given the authority to make all the decisions necessary to achieve a successful outcome. In general there is common agreement that the provision of sufficient resources is necessary for work processes to be carried out competently, whether those resources are human, material or financial. Statutory regulations and attendant codes of practice when addressing responsibilities regularly include a resources requirement, although what is frequently overlooked is that authority is a necessary adjunct to responsibility. How often has an individual been held responsible for a task or function where they have not been given the relevant authority to make the correct decisions necessary for success? That individual is usually the person subsequently held responsible or accountable when something does go wrong. Consequently responsibility is equated with blame, and blame has the habit of filtering down through the management hierarchy, rather than upwards.

Where each participant in a work situation is armed with the three elements, (authority, resources and competence) then the requirements for a preventative safety culture is met.

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[21] ILO, Promotional framework for Occupations Safety & Health, para. 26.

## Necessary Function in Organisational Structure

The belief that this [OSH] business is everybody's business is steadily gaining recognition as a core value, among enlightened organisations but that does not happen automatically. It takes a conscious act to make it a reality and vigilance, commitment and competence to sustain the belief.

For the concept of prevention as a universal responsibility to become successfully embedded in the organisations' values and effective within their operational methodology, an acceptable perspective on the roles of the various players in the organisational framework is required. Regardless of the socio-political environment in which an organisation exists it is fundamentally a holistic entity, whether it is a corporation wholly owned and controlled by a single individual or a co-operative owned and controlled by the all participants in the organisation. The effectiveness of an organisation is predicated upon each participant within the framework performing up to and within the parameters of their position and being influential in such directions as is necessary for the effective working of others. An effective organisation[22] is comprised of a range of roles or positions that are necessary for and whose function it is to achieve the successful outcome of the aims, objectives and targets of the organisation. Each role has a clearly defined and necessary function that is occupied by personnel who are competent, resourced and in possession of the appropriate level of authority to control their particular task.

Roles that exists above and beyond the functions needed to successfully execute the organisation's business are superfluous and create a draining effect on the vitality of core functions by abstracting from them authority, responsibility and resources. For example, if a financial manger exercises control over resources that should necessarily be controlled by operational

[22] McAleenan & McAleenan, "A Different Approach – Operational Analysis and Control", NSC 2002

managers, or a safety officer strays into the role of trying to manage the safety aspects of an operation the consequential outcome is to neuter the effectiveness and compromise the competence of operational staff. In the process you negate the practice of universal responsibility thus mitigating against prevention as a universal responsibility within each necessary function.

Companies using the OAC management model examine the requirements necessary for successful and therefore safe outcomes and ensure that the resources; human, material and financial, are in place to control their operations. The OAC approach is expandable from simple everyday tasks to the comprehensive task of governing the organisation. Its effectiveness requires that each functional role has a sphere of control and a sphere of influence. Individuals operating within the necessary functions must have the competence to manage within their sphere of control interacting with neighbouring functions to the extent necessary to co-ordinate their activities and communicate essential information, within each contributor's sphere of influence. Overlaps within the sphere of influence exist to the extent that they support smooth operations. Greater overlaps lead to an unnecessary duplication of role and a subsequent reduction in organisational effectiveness.

## Conclusion

It is the goal of the International Labour Organisation to have Prevention as a core concept accepted and implemented throughout the world of work. Equally there is a fundamental obligation that we all owe our neighbour a duty of care and this requires that we conduct ourselves in a manner that prevents harm and injury to him. Prevention should not be viewed merely as a policy goal, rather it needs to be recognised as a universal responsibility exercised by businesses globally and by all in the local workplace. When the circle of competence for each participant in the work environment is complete, that is individuals possessing the pre-determined skills have access to all of the necessary resources and have the authority to act within their sphere of control then the requirements for a preventative safety culture are met. Anything less is an abdication of responsibility. Organisations exercising corporate and individual responsibility work to ensure prevention is a universal responsibility and the success of their strategies will guarantee that the fall in the number of accidents at work continues.

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14th April 2005

## OAC as a Prevention Strategy - Case Study

In 1997 the operational analysis and control methodology was first introduced to Roads Service, a government agency in N. Ireland with circa 2,000 employees. At the time the Agency had six Safety Advisory Officers and a Senior Safety Advisor. A widely held feeling at that time was that they were the 'safety guys', the inference being that they were responsible for ensuring safe and healthy working conditions. The changing emphasis, post 1997, was an acknowledgement that all its employees, from members of the Board to operatives out on the ground had responsibility to ensure safe and healthy working conditions, within their sphere of control and influence[23].

The simple, although not simplistic, approach of OAC was designed to make this transition as smooth as possible. Safety advisors were reduced in numbers and assumed a more appropriate role of providing technical assistance when requested by management and staff. Two key requirements were central to the success of this approach;

1. The Board defined their priorities as, the OSH, free movement of the travelling public and Value for Money,
2. Competence was a principal requirement for employees and contractors, (noting that competence extends to having adequate resources, responsibility to achieve and the authority to act within their sphere of control).

The effectiveness of this approach is managed through controls assurance, senior management interventions, and a robust procurement process. In order to ensure consistency the control measures are defined and provided through operational safety control sheets, linked to method statements. The key message across the organisation is that competence is an absolute and that there is a duty of care and a duty to act upon every employee from the Boardroom down.

Since the introduction of OAC to Roads Service the reportable (recordable) accident levels have fallen by 50% from a high of 68 in 1998 to 34 for 2001. The rolling three-year average has fallen from 59.07 in 1998 to 38 in 2003. The prediction from preliminary figures for the 2004 calendar year is that the level will fall below the Chief Executive's target of 32. With each target met the Board set new and more challenging reportable accident reduction targets.

[23] McAleenan & Orr, "Safety – Turning the Event into a Process", 1999

# Operation Analysis and Control

is it safe

Operational Analysis and Control (OAC) is an approach to safety that ensures work operations are carried out in strict accordance with all relevant safe working procedures. OAC advocates that those who are involved in the project at all stages will have a contribution to make to the elimination or control of hazards.

OAC is a unique approach that works across jurisdictions and with all businesses regardless of size.

L'Analyse et la Commande Opérationnelles (ACO) est une approche à la sûreté qui assure des opérations de travail sont effectuées dans l'accord strict avec toutes les procédures sûr travaillantes appropriées.

ACO préconise que ceux qui sont comportés dans le projet à toutes les étapes auront une contribution à faire à l'élimination ou à la commande des risques.

OAC est une approche unique qui fonctionne à travers des juridictions et avec toutes les entreprises indépendamment de la taille.

**Analyse / Analise / Analysez**

What can cause harm?
Que pode causar o dano?
Que peut causer le mal?

What are you doing about it?
Que você está fazendo sobre ele?
Que faites-vous à son sujet?

Is it enough?
É bastante?
Est-il assez?

**Manage / Controle / Contrôlez**

What has to be done?
Que tem que ser feito?
Que doit être fait ?

What resources do you need?
Que recursos você necessita?
De quelles ressources avez-vous besoin ?

When does the operation need reviewed?
Quando a operação necessita revisto? Quand l'opération a-t-elle besoin passé en revue ?

**Review / Revisão / Revue**

Has the operation progressed as planned?
A operação progrediu como de planeamento?
L'opération a-t-elle progressé comme prévu ?

Detail the changes needed.
Detalhe as mudanças necessitadas.
Détaillez les changements requis.

List the improvement actions.
Aliste as ações da melhoria. Énumérez les actions d'amélioration.

# ISSA IMHOTEP Award Winner

- **Assessors begin the process by detailing the Project Tasks, including the objectives that have been established.**
- **Tasks are analysed and the range of operations necessary to achieve completion are identified. The assessor identifies all the hazards for each operation**
- **The assessor selects each hazard in turn in order to prepare the measures necessary to eliminate or control the hazard.**
- **Having completed all the assessments a full safety plan has been created, detailing all of the projects hazards and associated controls.**

**The OAC is supported by a complete suite of products and toolkits that will assist companies develop their new safety systems or improve their existing systems.**

- **Os assessores começam o processo detalhando as tarefas do projeto, including os objetivos que foram estabelecidos.**
- **As tarefas são analisadas e a escala das operações necessárias conseguir a conclusão é identificada. O assessor identifica todos os perigos para cada operação**
- **assessor seleciona cada perigo por sua vez a fim preparar as medidas necessárias eliminar ou controlar o perigo.**
- **Terminando todas as avaliações uma planta cheia de segurança foi criada, detalhando todos os perigos dos projetos e controles associados.**

**O ACO é suportado por um suite completo dos produtos e as ferramentas que ajudarão companhias desenvolvem seus sistemas novos de segurança ou melhoram seus sistemas existentes.**

- **Les assesseurs commencent le processus en détaillant le projet charge, y compris les objectifs qui ont été établis.**
- **Charge est analysés et la gamme des opérations nécessaires pour réaliser l'accomplissement sont identifiées. L'assesseur identifie tous les risques pour chaque opération**
- **L'assesseur choisit chaque risque alternativement afin de préparer les mesures nécessaires pour éliminer ou commander le risque.**
- **Après avoir accompli toutes les évaluations un plein plan de sûreté a été créé, détaillant tous les risques de projets et commandes associées.**

**L'ACO est soutenu par une suite complète des produits et les trousses à outils qui aideront des compagnies développent leurs nouveaux systèmes de sûreté ou améliorent leurs systèmes existants.**

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**Title** Competence: Redefining the Matrix of Authority

**Event**: Past, Present and Future

**Date:** September 26, 2007,

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**Competence - the Conception Principle**

Is there anything so elusive or thought provoking as defining competence? Let's start with this thought; "every worker is competent". In fact let us go one stage further and say that everyone is competent. We can explore definitions later, but it important to acknowledge this fact.

Now why would you imagine that to be so when the debate up to now has been about taught competence? However what of reasoning, integrity, honesty, creative thinking, visualising. Are these natural attributes not also an essential element of competence?

From the point of its conception a child has the ability and the instinct to survive. For that to happen effectively he needs to find nourishment, warmth, comfort and protection, which he gets from his mother. In those early days through to some period of months after its birth the child is totally dependent on his mother to provide for all of his needs, but eventually there comes a time when the child starts to talk, walk and develop the skills needed to survive as an independent person. As the child grows the degree of dependence he has on his parents, his teachers and his mentors diminishes. And so the journey is one from total dependence through to complete independence of thought and of deed.

In order to accept this it is necessary to acknowledge some basic truths about competence. The authors are happy to explore the skills, knowledge and ability aspect of the competence definition but first let's get to the core.

Is it possible that the natural instinct to survive is a core tenet of competence?

And if this is so then at a point where individuals do not possess all of the skills and resources needed to survive there is a level of dependence on others to provide assistance; the child and his mother; the new student and his teacher; new employee and her colleagues.

But as the individuals' skills, knowledge and ability grow their level of competence grows to a point where they can perform fully in their chosen occupation with confidence. And it is just as essential that as this journey progresses that the dependency on others will and must be allowed to diminish. Creating a false degree of dependency affects an individual's ability to achieve their full competence potential.

Just for one second consider how well an animal reared in captivity would survive in the wild.

**The 'What' in Competence**

HSE UK[1] states that; "Competence is the ability to do the work required to the necessary standard". This is a fairly simple statement that would appear to make sense of a complex issue. Yet the fact that the debate of what constitutes competence arises time and again serves to illustrate that the concept is neither agreed nor one that in many instances is fully understood.

[1] Approved Code of Practice for the Management of Health & Safety at Work Regulations (1999), HSE UK

When asked to define competency from a psychologist's perspective Dauphin[2] stated;

> "Competency must be defined quite broadly and eludes any concrete or overly specific definition...Competency means possessing the requisite capacities and knowledge base to undertake one's agreed upon functions with those whom a psychologist works. It means that one is able to perform in a professional manner."

In the Mind the Gap report, IOSH 2004 it was stated that "competence results from the overlap of three attributes: knowledge, skills and experience".[3] The paper went on to state that knowledge may be gained through formal education, training or on-the-job learning, skills are developed and honed through practical application and experience, like knowledge, needs to be current, relevant and specific.

The courts have also looked at the matter and as far back as 1977 the Supreme Court in Ireland, commenting on the qualities of a competent person, held that "having due regard to the age, skill and experience of a worker, he or she will know the hazards associated with their work and be able to apply the controls necessary to prevent harm".[4]

The concept of competence may appear to have been well thought out and a definition long established, but unfortunately it remains a poorly understood concept, fraught with multiple interpretations that ignore the natural aspects of competence and the impacts of imposed dependency. This in turn leads to many absurd requirements and negative assumptions about workers who do not meet these requirements.

For example, a narrow definition of competence, based on a requirement that a person be formally trained, requires evidence that that person has attended and received a ticket or certificate for attending specific courses albeit that they may have to be properly examined before obtaining their certificate. Such an approach detracts from the fact that training, formal education etc. is not and should never be conflated with competence. They are simply routes to developing a person's degree of competence and not always a necessary route, at that.

There are two sides to competence, the route by which it is acquired, inputs, and the observable qualities that determine that it has been acquired, outputs. Much of what is sought as evidence of competence, such as the certification at the end of an educational or training cycle is in fact evidence of input and often fails to take account of the actual capacity of the worker to apply such inputs in a competent manner.

Training or teaching cannot take place without learning occurring as a result. Where-as learning can occur without a teaching or training input. However, where learning occurs as a result of a teaching process, it does not necessarily follow that what was learned was what was intended of the teaching[5]. The examination and/ or assessment process goes some way

[2] Letter on Competency for Psychologists, Barry Dauphin, Ph.D. www.mspp.net/dauphincompetency.htm
[3] *Mind the Gap*, IOSH Research Workshop, 2004.
[4] *Dalton v Frendo* (1977), Irish Supreme Court
[5] For further exploration see also Ivan Illich *Deschooling Society* (1973)

towards addressing this issue, but often it measures what wasn't learned rather than what was, and then certifies on the basis of the proportion of intended learning that the candidate demonstrates. Training or teaching inputs may satisfy the requirements towards the acquisition of competence; however as stand-alone components they are not necessarily essential nor in some circumstances are they sufficient.

In a number of Latin American countries there have been remarkable developments in how technical institutions certify their students. Labour and Education Ministries are looking towards certification processes that recognise the real and proven capacities of workers regardless of how they were acquired.[6] In this perspective the outputs of the worker are the critical factors in determining competency, rather than the inputs.

A similar case may be made in respect of those who contend that competence development comes through experience and no matter how many certificates and degrees a worker has; it is no substitute for time served. Certainly experience has importance in competence growth but experience alone is not competence. If a worker spends 25 years on site doing the wrong thing time and again, can we rationally argue that he is competent simply because he has had 25 years experience?

Training and experience are both routes to competence; they are not in themselves competence.

In their consultation document Managing Competence for Safety-related Systems[7] the HSE stated that "competence involves much more than technical training, including attitude and behaviour as well as experience and knowledge of the application domain", and this is something that can be agreed upon because it is includes a recognition of the capacity of the competent worker in actual situations. In quoting from the 'Hazard *Forum Guidelines*'[8] they listed what they believe competence includes, such things as "qualifications, experience, and qualities appropriate to their duties", including;

- "Such training as would ensure acquisition of the necessary knowledge of the field for the tasks which they are required to perform;
- adequate knowledge of the hazards and failures of the equipment for which they are responsible;
- knowledge and understanding of the working practices used in the organisation for which they work;
- the ability to communicate effectively with their peers, with any staff working under their supervision, and with their supervisors;

[6] International Labour Organisation/ CINTERFOR report on recent developments in competency based training in Latin America and the Caribbean, Jan 2003. http://www.ilo.org/public/english/region/ampro/cinterfor/temas/complab/observ/index

[7] *Managing Competence for Safety-related Systems*, HSE (UK) consultation document, 2005

[8] *Safety-related systems: Guidance for engineers* (Issue 2, 2002) The Hazards Forum, ISBN 0 9525 103 0 8

- an appreciation of their own limitations and constraints, whether of knowledge, experience, facilities, resources, etc., and a willingness to point these out."

However useful a list this may be it does not in fact construct an adequate working definition of what competence is. Three of the bullet points concern knowledge, the absence of which may or may not negatively impact on a persons' competence but the possession of which does not necessarily confer competence. A fourth relates to the ability to effectively communicate up and down the hierarchy, but here again there is no necessary connection between the ability to communicate and the competence of the individual. It will all depend upon the circumstances as to whether it is a relevant criterion or not. And finally, being able to appreciate your own limitations is a negative factor and, though important, defining what competence is should not fall down to an ability to recognise what we cannot do when the ability to recognise what we can do does not feature in the list.

The Law Society in Scotland[9] believes that competence in respect of practicing lawyers can be defined as the combination of:

- Technical knowledge;
- Commerciality, which comes from general commercial awareness and sector knowledge;
- Core skills; and
- Experience, or the opportunity to gain experience under supervision.

Whereas the legal test for [mental] competence is set out in Justice Thorpe's decision in Re C (Adult: Refusal of Medical Treatment) (C was a patient at Broadmoor Hospital suffering from schizophrenia who refused amputation of his gangrenous foot), describing it as:

> "First comprehending and retaining information, secondly, believing it and thirdly, weighing it in the balance to arrive at a choice."

In 2004, Expert Ease International developed a workable definition of competence that asserted that it is the ability to skilfully perform repeatedly to specific standards.[10]

As with the ACoP definition (above) this definition went to the core of what competence is, namely that it is about performance, the ability to do something and moreover to do it consistently to a required standard.

It says nothing about how the competent worker gains his competence which, although relevant it is not always necessary to know the answer to the "how" question. What is central and necessary is the workers skilful ability to perform a task. It entails not simply knowledge

[9] Law Society Scotland – (http://www.journalonline.co.uk/article/1004318.aspx )

[10] "A more appropriate definition of competence would be *the consistent skilful application of skills and knowledge to any specified work operation* (at whatever level that may be within the company), where the use of the term skilful implies conducting the operation to the highest standards within the field". *Safety in Design – A Risk Assessment Approach*, McAleenan and McAleenan 2004, presented to NSC June 2004.

and understanding of the task and the work processes into which the task fits, but it demands the ability to exercise control over the task performed[11].

The competent worker is more than someone who performs skilfully. A well designed machine can do that. Notwithstanding the alienation that results from the modern mode of production the worker is not a machine although processes and systems, such as those espoused by Henry Ford and FW Taylor, have driven him to being treated as such and into feeling that he is merely a cog in it.

Definitions of competence, at their most basic, can be developed whilst ignoring that which is essentially human about the worker, namely that he is a conscious, self-aware, decision-making being. That he is so is recognised in the previously referred to developments in Latin America, INTECAP (Instituto Técnico de Capacitación y Productividad) in Guatemala for example recognises three types of competency;

- Basic, including the ability to read and interpret texts, apply numerical systems and express oneself;
- Generic including analysing and evaluating information in particular occupational fields, working as a team, contributing to the maintenance of safety and hygiene, planning work etc; and
- Specific, including technical knowledge and skills associated with executing particular production functions.[12]

To disregard this fundamental facet of humanity is to reduce workers to being no more than automatons. Therefore to avoid such a repugnant conclusion the competent worker must be regarded as having both the resources necessary to carry out his tasks and the authority to decide on the appropriate action he must take.

The resourcing of workers and production appears non-problematic in theory, and legislatively there is a requirement that workers are indeed adequately and sufficiently resourced in order to carry out what is required of them. However, the latter concept, that of decision making authority resting with the worker, is one that features little in the theoretical debate on and the practical application of arrangements for competence.

Even in the sources referred to above, the competent worker, as someone being appreciative of their own limitations and being willing to point them out; is not the same thing as being able to make authoritative decisions on whether and how to carry the task. What is inherent in that point is that the competent person may still be required by a higher authority to carry out the task irrespective of what he has said about his limitations. And that higher authority may be based on ownership of the means of production, on supervisory and managerial ranking, or on a functional overlap between departments or perceived roles of individuals. In other words,

[11] The meaning of competence is explored further in *Prevention – A Universal Responsibility*, McAleenan & McAleenan, 2005, presented to the World Safety Congress, September 2005

[12] http://www.ilo.org/public/english/region/ampro/cinterfor/temas/complab/observ/ii.htm

authority in the hands of the competent worker is negated by hierarchical mechanisms for decision-making that have little to do with competence.

**What then does it mean to be competent?**

The ILO has welcomed the analyses of competencies in Latin America and the Caribbean "as a breath of fresh air in the pedagogy of training" and recognises that along with knowledge and skills, competence includes the capacity to analyse, to solve unforeseen problems, and a commitment to the objectives of the job.

Competence is more than the ability to repetitively carry out an activity with skill and to a specified standard. Properly resourced and with knowledge and understanding of what is required, it is the ability to control the work task and the environment within which it takes place to achieve a desired outcome.

Remove any of the above elements and competence is compromised, even negated.

In his letter to the Department of Community Health regarding competency for psychologists, Dauphin advanced our understanding further by arguing that competency is individual in nature "since every individual psychologist brings unique skills and personality characteristics to every situation in which he functions... To set a uniform definition for all psychologists is meaningless, since competence can only be considered in terms of the individuals and situations to which one is applying one's professional expertise".[13]

In saying that where does it take us? What difference will it make to current practice to adopt another definition of competence?

A competent workforce effectively engaged in any project redefines the matrix of authority such that any superfluous functions are identified and discarded. Such functions serve only to neuter the effectiveness of the worker/ group through confusion, acting to cross-purposes, engendering unnecessary hierarchies and fundamentally abstracting authority from the worker/ group.

By way of an example, management is often placed in a hierarchical relationship to operatives with operatives being the subordinate players. There is no necessary logic for such a hierarchy but we have it nonetheless. Straight away the hierarchy creates dichotomies between the operatives who produce the end product and the managers who are tasked with ensuring that the operation proceeds apace.

The first dichotomy is that management and operation are discrete functions. In making this separation between operation and the management of the operation a class of abstraction has been created that on its own is an irrelevancy, is superfluous. Management needs the operative to rationalise its own existence, but in the process must negate the idea that the competent worker is capable of managing what he is doing, either individually or as part of larger work units, and in so doing denies his/ their competence.

[13] Barry Dauphin, Ph.D., http://www.mspp.net/dauphincompetency.htm June 2005.

A second dichotomy is one of authority; the operative defers (by imposition not choice) to the authority of the manager. This is a logical corollary of the negation of the worker's competence to manage; the 'non or lesser' competent person must defer to the 'more' competent. As a result key decisions about the way in which the worker carries out his activities, (as determined by a safety manager), how, and how sufficiently he is resourced, (as determined by a finance director), when he carries them out (as determined by a contracts manager) and whether he should or should not proceed, (as determined by an operations manager), are taken by persons who are not only not carrying out the work but are not necessarily competent in the work activity itself.

Without the authority to make these critical decisions, with his capacity to analyse negated and the power to resolve unforeseen problems annulled an imposed dependency on external decision makers is reinforced. The competent worker is neutered.

A further dichotomy is one of status; the manager has a higher status than the workers who carry out the task. Such status follows on from having authority over how and when workers perform and with that comes the perks of status, higher incomes, offices, separate eating areas and white coats. These are the building blocks of the wall that separates workers from management and reinforces the separation of operation and management of the operation. And with this barrier arises discontent, absenteeism, 'insubordination' and a whole sleugh of other conscious and unconscious behaviours that result in output failures, including accidents and injury.

This separation of functions from the competence necessary to carry out any given work operation often consigns those functions to being a mere adjunct to the operation that can be ignored, even discarded when circumstances warrant. This is the cry all too often heard; when finances are tight, health and safety resources are cut. Indeed in the 1990s when re-engineering and downsizing were the buzzwords for corporate management it was the ranks of middle management that were decimated and industries continued with the two tiers of senior management and workers. What could be a more telling indictment of the superfluity of a disconnected management function?

**Reservoir of Talent**

But in these early years of the 21st century, the lessons have not been learned and the dichotomy between management and operation continues to problematic. However, one company, Semco in Brazil, turned the economic crises of the 1990s to their advantage and, re-engineering in a way unlike everyone else, were able to create new business models and work structures that took the company from near liquidation to being one of the most successful businesses in Latin America.

Semler, President of Semco[14] (2003) stated that "Accepting that there is no such thing as a 'special worker' perfectly suited for one company means accepting worker individuality. And

[14] *The Seven-Day Weekend*, Ricardo Semler (Dr), 2003

once you do that, you set the stage for making the most of that individuality by encouraging workers to tap their inner reservoir and find a balance between their aspirations and the company's."

Two things worked for Semco. Firstly after working with traditional departmentalised management structures, the company gave engineers their head and allowed them to explore and develop new product lines. This extended to setting up satellite units to develop, produce and market the products.

Secondly, in the face of bankruptcy, workers and managers agreed to wage cuts in exchange for a greater share of the profits on condition that they too were given a free hand in approving every item of expenditure. This led to the workforce performing many roles compared to what they traditionally played; they became knowledgeable about all aspects of the company, including its finances; they made decisions about who to employ, what to buy in the supply chain, when to buy, who from, even what to manufacture, to what standards, and how it should be marketed. The company succeeded.

The success of the company was due to the second innovation, the recognition that the workforce are competent to receive and understand information about all aspects of the company, are competent to make the critical decisions about how the company is organised and run, are competent to make decisions about what is produced and how it is produced, and finally the competent workforce does not require, in fact may only succeed in the absence of a multi-layered hierarchy and its concomitant redundant functions.[15]

It is a universal requirement that companies of all sizes appoint competent persons or bring them to the required level of competence before assigning them tasks within the workplace. Vassie, (2004)[16] in the above-mentioned IOSH paper presented findings from a number of research papers that increasing competitive demands on businesses have resulted in new ways of working and greater emphasis on competence throughout the workforce. Whilst advising caution regarding the limitations on the various studies, the issue of individual OSH competence was considered a necessary (though not a sufficient) factor in organisational OSH competence.

By extrapolation the competence of workers to organise and manage their work activities individually and collectively may similarly be regarded as a necessary factor for the competence of the organisation/ company. Michael Albert[17] a leading US economist and author of the theory of participatory economics posits self-managing decision making as a viable alternative to top-down management structures and cites examples of projects in Argentina. In his model workers having balanced job complexes replace the superfluous functions inherent in hierarchical management structures. This is akin to the Semco experience. In the Parecon model organisations too combine tasks into jobs so that the

[15] *Maverick*, Ricardo Semler, 1999, Random House Publishers, ISBN 0712678867
[16] Dr Louise Vassie, University of Leicester, contributor to "*Mind the Gap*"
[17] *Parecon, Life After Capitalism*, Michael Albert, 2003 Verso Books ISBN 1 84467 505 X

overall empowerment effect of each job is like the overall empowerment effect of every other job. The worker exercises his competence through authority and control of his work activity and in conjunction with other workers in the same workplace. In the OAC model this means that each functional role has a sphere of control and a sphere of influence. Individuals operating within the necessary functions must have the competence to manage within their sphere of control interacting with neighbouring functions to the extent necessary to co-ordinate their activities and communicate essential information, within each contributor's sphere of influence.[18]

**Conclusion...**

In these models of competence, and in the way the courts view the competent worker, there lies a map for the future development of the workforce. When applying the logic to OSH it can be concluded that OSH practitioners would gradually work themselves out of jobs as workers and management became sufficiently competent and resourced in OSH.[19]

What then is the future role of the safety professional? To facilitate their clients/ employers getting to a point where they no longer need assistance and they have the confidence and autonomy to get on and do the job themselves.

If we accept that the competent worker is skilled, authoritative and in control of his work then we must too look to new social mechanisms that support him in that function...

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9th September 2007

The authors invite readers to submit comment or critique of this paper or suggestions for new social mechanisms to;

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[18] *Prevention – A Universal Responsibility*, McAleenan & McAleenan, 2005
[19] *Mind the Gap*, IOSH Research Workshop, 2004.

# Encouraging meaningful and effective consultation about occupational health and safety (OHS) in the construction industry: a recognition of workforce competence

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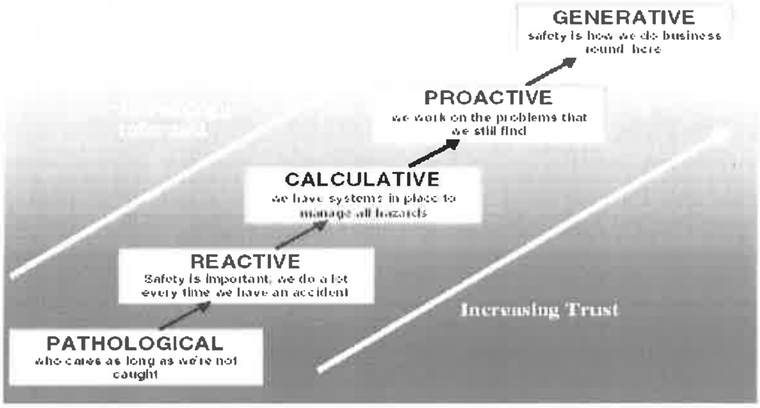
## Introduction

It is overwhelmingly acknowledged that workforce involvement is vital to occupational health and safety (OHS) success (Johnstone 2005; Walters, Nichols, Connor, Tasiran and Cam 2005; Lingard and Rowlinson 2005; Wilkinson, Dundon, Marchinton and Ackers 2004; Page 2002; Hart 2002; Bell and Phelps 2001; Committee on Health and Safety at Work 1972). An acknowledged mechanism for this to occur is via the process of consultation; which is mandatory under the *Occupational Health and Safety Act 2004 (Victoria).* Elsewhere in the world, for example in the US the ANSI standard; Z10 (2005) for occupational safety and health management systems states; "...safety responsibilities must be recognized as a part of each job at every organizational level" while the International Labour Organization standards requires that employers have access to sufficient competent assistance. The natural conclusion to such a premise is that real and meaningful consultation between workers and management is not only desirable but essential.

But for consultation to be meaningful and effective in terms of OHS success, it is considered that issues such as trust, honesty, integrity, respect, support, commitment, sincerity and inclusiveness be recognised and implemented by all participants in the consultation process (Walters 2006; Walters et al. 2005; Shearn 2004; Hart 2002; Blewett 2001; Walters and Frick 2000). These issues or principles are primarily concerned with moral and ethical considerations and are greatly influenced by people's ethical and moral beliefs and their cultural ways of life (Emmet 1966). Transposing this into an organisational and workplace context, the culture of the organisation becomes pivotal in determining how the issues required for meaningful and effective consultation are applied. Recognising that a competent, resourceful worker can make the right choice to effect a successful outcome will remove some of the barriers between those who make the decisions and those whose task it is to carry them out. Such an approach is consistent with the cultural concept of occupational health and safety, which supports the paradigms of social and cultural relations at the workplace (Hvid 2001). McAleenan and McAleenan (2005) stated that "organisations that are good at managing OSH create an authoritative, multi-directional, leadership structure to maximise the contribution of competent individuals and groups in the delivery of successful prevention and loss control programs". A useful model that espouses the social and cultural relations paradigms is Hudson's Evolutionary Safety Culture model (Hudson 2003). Hudson's model is based upon an evolutionary process of cultural maturity, set out in a framework or scale of five different maturity levels.




**The Hudson Evolutionary Safety Culture Model** Source: Hudson (2003a)

The model is seen as part of a process of an organisations' evolution towards a full safety culture (Hudson 2001). According to Hudson (2003), the notions of organisational culture and the subsequent understanding of both safety culture and safety management, will differ according to the levels of cultural maturity that an organisation achieves. Hudson (2003) saw the process of moving up the ladder of maturity reliant upon the generation of trust and the developing of what he, and Reason (1997), called informedness. This informedness constitutes the cultural approach of trust – in essence meaning that a no blame culture commences to be implemented and that information, regardless whether it be good or bad news, is not only welcomed but actively encouraged (Reason 1997). This information flow, which is fundamentally a process of the effective management and transfer of knowledge, skill and competence of a workforce is synonymous with meaningful and effective consultation (Sveiby and Simons 2002; Smith 2001). Meaningful and effective consultation is positively associated with a high degree of workforce involvement which not only has a profound influence on organisational culture (Hvid 2001), but is acknowledged and recognised as being vital to OHS success.

## Risk Management, consultation and risk identification and assessment

If the epicentre of OHS success is an indication of meaningful and effective consultation, then logic and practice suggests that the process of risk identification and risk assessment; key components in the process of risk management (Tchankova 2002) should also involve meaningful and effective consultation. According to Quinlan and Bohle (1991) '... risk assessment is a process for estimating the probability that a specified undesirable outcome will result from specific duration of exposure to a specified hazard' (p.376). Importantly, they argued that the most contentious issue or aspect of the risk assessment is the decision of what constitutes an acceptable risk? In what Viner (2002) called the 'imprecise science' of risk assessment, the question of exactly what understanding of the accident/ill health phenomenon are workplace risk assessments actually being based upon, needs to be better understood (Borys 2001). Too often the risk factor becomes a measure of personal experience and opinion, as opposed to any scientific and or objective exercise in controlling the occupational hazard at its source; the most preferred and effective option. Furthermore, if the assumptions that the risk assessment is based upon are later proven false, or are in fact no longer true, the risk assessment itself becomes worthless (Keltz 2001). Quinlan and Bohle (1991) argued that because of such an imprecise approach and the degree of uncertainty about what is or is not acceptable, the final decision of what is deemed to be acceptable should emanate from a social and political process involving governments, employers, unions, health professionals and the wider community. In a workplace environment, this equates to employers and workers and their representatives sitting down and engaging in consultation over the issues in an open and transparent manner; utilizing the knowledge, skill and competence of all players in an effort to come up with the most effective and agreed hazard control measures.

McAleenan and McAleenan (2002) championed the operational analysis and control principle as an alternative to risk management, which goes to the real starting point; the work operation, and determines from the outset what is needed to achieve a safe outcome, firmly establishing the competent worker as the cornerstone. Good management is concerned with controlling the operation in order to achieve its objectives. Management must be focused on the key players [competent workers] and the desired outcomes, rather than simply the process and methodologies if it is to achieve and maintain its effectiveness. Truly effective management is dynamic and reliant upon consultation with and acceptance of the input from competent workers. It must recognise and respond appropriately to factors that impinge upon the outcomes and ensure that these desired outcomes are maintained.

Kelly (2007) believed that such knowledge, skill and competence, be it individually or organisationally, should be considered in the context of what she described as the overall power and authoritarian structures within a workplace. In her literature based review on the relationship between knowledge and power within an organisational cultural perspective, it was Kelly's opinion that there needed to be a successful development of what she called a knowledge sharing culture, which would then engender a development of trust within an organisation. Kelly (2007) believed that knowledge should no longer be regarded as a power resource, but more as a communal resource to be freely shared amongst the entire organisation in order to facilitate the joint and mutually beneficial achievement of organisational and professional goals.

## Conclusion

While the ideas presented in this paper have not yet been fully tested in the field by the author, past research indicates that the recognition, management and implementation of the knowledge, skill and competency of an organisations' workforce has a far greater impact when there is a culture within the organisation that recognizes, develops and applies moral and ethical principles such as trust, honesty, integrity, respect, support, commitment, sincerity and inclusiveness.

While these principles may not be explicitly required under most types of legislation, they are nonetheless considered necessary if particular pieces of legislation, such as OHS legislation, are to be implemented and carried out effectively (Emmet 1966). In terms of OHS, such a process translates to the full and active participation of workers, utilizing their knowledge, skill and competence via meaningful and effective consultation, conducted in a mature, responsible, ethical and inclusive approach.

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# Competence – A Leap of Faith

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## Introduction

A competent worker is skilled, authoritative and in control of his work. What then are the social mechanisms he needs to support him in that function? And what role does the OSH professional have in this bold new venture. McAleenan and McAleenan (2007) examined competence and the matrix of authority and discussed various emerging ideas from across the globe. The authors posited that the core tenet of competence is the natural instinct to survive and that that principle, when applied to the workforce, is threatened when a third party interferes and stymies the development process. In the US safety management standard, ANSI/ AIHA Z10 – 2005, it states "...safety responsibilities must be recognized as a part of each job at every organizational level".

The International Labour Organization (ILO) in the 2001 occupational safety and health management systems standard stated that "The employer should have, or should have access to, sufficient OSH competence to identify and eliminate or control work-related hazards and risks and to implement the OSH management system".

Considering the ILO and the ANSI/ AIHA Z10 statements together it could reasonably be concluded that employers are duty bound to employ competent people and to further develop that competence to meet the ongoing needs of the worker and the company. This competent assistance, often mistaken for the need for a single OSH competent person is not something that is within the realm of the few, rather the whole. The leap of faith, therefore, is the one that realises that competence within everyone's domain is inherent and that with the proper authority and resources it can grow to the benefit of the individual and his employer.

In building a sustainable business there can be no future for the old style OSH professional taking charge of safety matters while the real work is carried out. Workplace operations and safety are inextricably linked and lie firmly within the province of the workforce and the management team. The Institution of Occupational Safety and Health (2004), reported "…it can be concluded that OSH practitioners would gradually work themselves out of jobs as workers and management became sufficiently competent and resourced in OSH", recognizing that the time has come to be creative about the future roles. At the World Congress on Safety and Health (McAleenan, P, 2005) and again at the Ireland IOSH 25th/ 40th Anniversary conference (McAleenan, C, 2007) the challenge to delegates was to work themselves out of a job. It is time for the worker and his employer to be sure that there are no redundant roles.

## A New Social Order in the Workplace

In the early years of the 21st century the dichotomy between management and operation continues to problematic. However, one company, Semco in Brazil, turned the economic crises of the 1990s to their advantage and, re-engineering in a way unlike everyone else, were able to create new business models and work structures that took the company from near liquidation to being one of the most successful businesses in Latin America. Semler (2003) stated that;

> *"Accepting that there is no such thing as a 'special worker' perfectly suited for one company means accepting worker individuality. And once you do that, you set the stage for making the most of that individuality by encouraging workers to tap their inner reservoir and find a balance between their aspirations and the company's."*

Two things worked for Semco. Firstly after working with traditional departmentalised management structures, the company gave engineers their head and allowed them to explore and develop new product lines. This extended to setting up satellite units to develop, produce and market the products. Secondly, in the face of bankruptcy, workers and managers agreed to wage cuts in exchange for a greater share of the profits on condition that they too were given a free hand in approving every item of expenditure. This led to the workforce performing many roles compared to what they traditionally played; they became knowledgeable about all aspects of the company, including its finances; they made decisions about who to employ, what to buy in the supply chain, when to buy, who from, even what to manufacture, to what standards, and how it should be marketed. The company succeeded.

The success of the company was due to the second innovation, the recognition that the workforce are competent to receive and understand information about all aspects of the company, are competent to make the critical decisions about how the company is organised and run, are competent to make decisions about what is produced and how it is produced, and finally the competent workforce does not require, in fact may only succeed in the absence of a multi-layered hierarchy and its concomitant redundant functions

Sir John Egan (1998) reporting to UK's Deputy Prime Minister stated that;

> *"If the industry is to achieve its full potential, substantial changes in its culture and structure are also required to support improvement. The industry must provide decent and safe working conditions and improve management and supervisory skills at all levels"*

What Egan was talking about was the establishment of a competent and sustainable construction industry, achieved through commitment at all levels in the industry, which means that;

- Clients and their designers work in partnership with the contracting industry, the health and safety enforcement agencies and fellow client bodies,
- Board members' commit to making safety work for all their staff and for all those affected by their work,
- Business strategies and objectives are prefaced with a commitment that goals will be achieved in a manner that does not cause harm to workers or end-users,
- Companies go beyond compliance where OSH is critical, and
- Individuals workers and employers will act as they would expect others to act, i.e. competently.

## Education – A means for Social Change

In a number of Latin American countries there have been remarkable developments in how technical institutions certify their students. Labour and Education Ministries are looking towards certification processes that recognise the real and proven capacities of workers regardless of how they were acquired. In this perspective the outputs of the worker are the critical factors in determining competency, rather than the inputs.

The ILO has welcomed the analyses of competencies in Latin America and the Caribbean "as a breath of fresh air in the pedagogy of training" and recognises that along with knowledge and skills, competence includes the capacity to analyse, to solve unforeseen problems, and a commitment to the objectives of the job. Competence is more than the ability to repetitively carry out an activity with skill and to a specified standard. Properly resourced and with knowledge and understanding of what is required, it is the ability to control the work task and the environment within which it takes place to achieve a desired outcome. Remove any of the above elements and competence is compromised, even negated.

Freire, the Brazilian educator's concepts that education [in the workplace] is a dialogue between student and teacher where the student is given the tools to allow them to reach a critical consciousness of the main goals, where applied, allows education to achieve its profound purpose. In a new era of workplace education with clear and precise objectives the barriers of the past can be broken down and workers, properly educated, with the correct tools; physical and mental, can deliver a consistent and correct product without unnecessary interference.

## OSH Professionals: The Final Chapter?

OSH professionals considering their role into the future can look towards education as a means of delivering complete independence for the employer. Education in this style of approach can be a force for good not a crutch to prop up an ailing system.

OSH professionals are still selling products, services, training and compliance programs to ensure that safety violations are a thing of the past; so what is the problem? Certainly there is the intellectual and technological capability to ensure that these failures should not have happened, so does it mean that the issue of compliance falls to employee and management competence? It would be wrong to suggest that workers or their employers are not competent to do their job, and not everyone is just plain greedy and uncaring about their workforce. Safety properly exercised will not cost a company, but will reap plenty of benefits. So what prevents the exercise of competence? The most likely answer is that the person carrying out the job does not always hold the decision-making authority. There is a dichotomy between those who do the work and those who decide what is to be done and how it is to be done. In those circumstances there arises confusion at best and a direct conflict at worst between the doers and the deciders, which results in failure and that in turn leads to injury and fatality. What is important is that those of OSH professionals who produce goods or deliver the services should know where the problem lies and provide guidance to their clients on these issues.

## Epilogue

In a new social order where workers and employers recognise and engage with each other's competent status;

- Workers have authority, resources and responsibility for decisions that affect their livelihood,
- Education is the tool for delivering positive changes,
- Workplaces have become virtually injury-free and the OSH laws have begun to lose prominence, and
- OSH professionals having helped to guide the change then faded out.

That is the vision and the challenge for today's OSH professionals. Are you up for the challenge?

By

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# Competence – A Leap of Faith(역량 – 믿음의 도약)

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## 머리말

역량있는 일꾼은 기술과 정당한 권한을 부여받아 자신의 일을 장악하는 사람입니다. 그렇다면, 그 기능의 경우에 스스로를 뒷받침하는 데 필요한 사회적 기제(메커니즘)란 무엇입니까? 그리고 OSH(산업안전보건) 전문가는 이와 같은 대담한 모험 가운데 어떠한 역할을 맡고 있을까하는 것입니다. McAleenan 및 McAleenan(2007)은 역량, 권위의 메트릭스 및 전세계에서 논의를 거쳐 다양한 모습으로 떠오르는 아이디어들을 조사하였습니다. 저자들은 역량의 핵심적인 견해로서 생존하기 위한 자연스러운 본능이며, 그 원칙을 근로자의 인력에 적용할 경우, 제3자가 개발과정을 간섭하고 방해하면 위협을 받습니다. 미국 안전관리표준의 경우, ANSI/ AIHA Z10 – 2005에서 규정하기를 "...... 안전책임은 모든 조직층에 각 직무의 일환으로서 인식해야만 한다"고 되어 있습니다.

국제노동기구(ILO)는 2001년도 산업안전보건관리시스템 표준편에서 "고용주는 충분한 OSH 역량을 보유하거나 역량에 접근, 이용하여 작업에 관련된 유해성과 위험을 식별 및 제거, 또는 통제해야 하며, OSH 관리시스템을 구현해야 한다"고 규정하고 있습니다.

ILO 및 ANSI/ AIHA Z10의 주장을 함께 고려해보면, 고용주는 역량있는 인재를 고용하고 종업원과 회사의 지속적인 필요를 충족시키기 위해 역량을 추가 개발해야 하는 의무가 있다는 합리적인 결론을 내릴 수 있습니다. 이와 같은 역량있는 지원의 경우, 전체가 아닌 소수의 영역 내에서는 별로 유능하지도 않는 단 1인의 OSH 역량있는 종업원을 필요로 하는 실수를 빈번하게 야기합니다. 그러므로 믿음의 도약은 모든 사람의 영역 내에서의 역량은 타고난 것이며 적절한 권한위임과 자원을 통해 개개인과 고용주의 이익으로까지 키울 수 있다는 점을 여실히 나타내는 것입니다.

지속가능한 사업을 확립하는 가운데 '실제 일'이 다른 어딘가로 진행되는 한편, 안전관련 사항을 책임지고 있는 진부한 스타일의 OSH 전문가의 미래란 있을 수 없습니다. 작업장 운용 및 안전은 빠져나갈 수 없게 서로 연결되어 있으며, 인력과 관리팀 분야 내에서 확고하게 존재합니다. 미산업안전보건연구소 (NIOSH: 2004)의 보고에서는 "...... OSH 의료서비스 제공자들은 작업자들과 경영진의 능력이 충분해지고 OSH에서 자원을 공급받음에 따라, 자신들이 점차 실직하게 된다는 사실이 포함될 수 있다."면서 향후의 역할에 있어 창의적으로 대처해야 할 시점이 다가왔다고 인식하고 있습니다. 세계산업안전보건대회 (World Congress on Safety and Health: McAleenan, P, 2005) 및 Ireland IOSH 25/40주년 기념대회 (McAleenan, C, 2007) 에서 다시 대표단이 직면한 도전은 자신들의 실직문제였습니다. 근로자들과 그 고용주들에게는 중복된 역할이 없으며, 안전작업지침에 대한 장애물이 됨을 확인하게 되었습니다.

## 작업장의 새로운 사회적 질서

21세기 초에는 관리 및 운영 사이의 이분법이라는 문제점이 해결되지 않고 지속하고 있습니다. 그러나, 브라질의 Semco라는 회사에서는 1990년대의 경제적 위기를 기회로 반전시키고, 다른 모든 이들과는 색다른 방식으로 재건하면서 거의 청산과정에 처하다시피 한 회사를 남미

최고의 성공기업들 가운데 하나로 우뚝 서게 한 것입니다. Semler(2003)의 표현을 따르면,

"이와 같은 '특별한 근로자' 요인이 회사에 완벽하게 맞아떨어졌음을 받아들이는 경우는 근로자의 개성을 인정하는 것을 의미합니다. 일단 이 경우에는 근로자들을 고무하여 자신 내면의 저장고 마개를 열고 개인과 회사의 기대목표간에 균형을 유지함으로써 그 개성을 십분 활용하기 위한 사전준비를 실시하는 것입니다."라고 합니다.

Semco 에서는 2가지 사항이 효과를 나타냈습니다. 전통적인 부문별 관리구조를 통해 작업을 실시한 후 첫째로, 회사에서는 엔지니어들에게 그들의 지휘권자를 세워주고 신제품계열의 연구조사 및 개발하도록 조치하였습니다. 이에 따라, 위성 단위부서들을 확대하여 해당 제품의 개발, 제조 및 마케팅까지 담당하도록 한 것입니다. 둘째로, 파산에 직면해서는 각 지출항목을 승인하면서 그들에게도 자유재량권을 부여하는 조건으로 이윤의 대부분을 포기하고 근로자 및 관리자들이 임금인하에 합의했습니다. 이렇게 하여 전통적으로 수행해 온 바와 비교하면, 여러가지 역할을 수행하는 전종업원 인력의 탄생을 보고, 회사의 재정분야를 비롯한 회사의 다방면을 깊이 알게 되는 효과를 얻게 되었으며, 고용대상, 공급사슬을 통한 구매대상, 구매시기, 구입처, 심지어는 어떠한 표준에 맞추어 제조할 것인가라는 제조대상, 그리고 마케팅 방법론에 이르는 결정을 내리게 되었습니다. 본 회사는 성공을 거두었습니다.

회사의 성공은 2차적인 혁신에 힘입었으며, 전종업원들이 자사의 여러가지 측면에 관한 정보를 얻어 이해할 수 있게 된 점, 당사의 조직 및 운영방법에 관하여 매우 중대한 결정을 내릴 수 있게 된 점, 생산제품 및 생산방식에 관한 결정을 내릴 수 있게 된 점, 끝으로 역량있는 근로자 인력은 필요로 하지 않는다는 점을 인식함에 따라, 사실상 다층적 계층구조 및 그 부수적인 여분의 기능들이 없는 상태에서의 성공만 거둘 수 있습니다.

영국 부총리실 산하의 John Egan 경의 보고서(1998)에 따르면,

"업계가 충분한 잠재력을 발휘하려 할 경우, 그 문화 및 구조의 실질적인 변화 또한 개선을 뒷받침하는 데 필요합니다. 업계에서는 반드시 훌륭하고 안전한 작업환경을 제공하고 관리 및 감독기술을 모든 수준에 걸쳐 개선해야만 합니다."라고 주장합니다.

Egan 이 언급한 것은 능력있고 지속가능한 건설업계의 확립, 업계의 모든 수준을 대상으로 전념함으로써 성취하며, 다음과 같은 의미를 부여합니다:

- 의뢰고객 및 소속 디자이너들은 업계, 보건 및 안전감독기관 및 동업 의뢰고객사들과의 계약을 통해 일한다
- 이사회 구성원들의 전 직원 및 직원의 근무로 영향을 받는 전체 대상들을 위하여 안전작업에 대하여 전념한다
- 사업전략 및 목표는 근로자 또는 최종 사용자들에게 해를 끼치지 않는 방식으로 목적을 성취할 것이라는 약속으로 시작한다
- 회사들은 OSH가 결정적으로 중요한 분야에서는 협력 이상으로 일한다
- 근로자 개인 및 고용주들 자신들은 타인들이 행동하되, 역량을 발휘할 것으로 기대하게 바와 같이 행동할 것이다.

## 교육 – 사회적 변화를 위한 수단

많은 남미국가들의 경우, 전문대학에서 학생들에게 인증하는 방식의 획기적인 개발을 수행해 왔습니다. 노동 및 교육담당 정부부처에서는 실제적이며 입증된 근로자의 능력을 습득방법에

상관하지 않고 인정하는 인증절차로 기울고 있습니다. 이와 같은 관점에서 보면, 역량을 결정하는 데 있어 입력물보다 오히려 근로자의 생산하는 출력물이 결정적인 요인이 됩니다.

ILO에서는 남미 및 카리브연안지역의 역량분석을 "교육훈련의 교육학 분야에 신선한 공기의 호흡"으로서 환영하며, 지식 및 기술과 더불어 역량이란 분석능력, 예기치 못한 문제의 해결능력, 및 직무목표에 대한 전념을 포함한다고 인식합니다. 역량은 기술을 사용, 특정 기준에 맞추어 반복적으로 활동을 지속하기 위한 단순한 능력 이상의 그 무엇입니다. 적절하게 자원을 활용하고 필요한 바 지식과 이해력을 사용하여 원하는 결과를 얻기 위해 일어나는 대상 안에서 작업과업 및 환경을 제어하는 능력입니다. 위의 요소 일체를 제거하고, 역량은 손상을 입되 심지어는 부정마저 당하게 됩니다.

교육[작업장에서의]은 학생에게 수단을 부여하여 주요 목적의 비판적 의식단계에 이르도록 허용하는 자리에서 가지는 학생과 교사간의 대화라는 브라질 교육학자 Freire 씨의 개념이 적용되는 현장에서는, 교육으로 하여금 그 심오한 목적을 달성할 수 있도록 합니다. 작업장 교육의 새로운 시대에 과거의 장애물이 무너질 가능성이 있고 근로자들이 올바른 도구를 사용해 제대로 교육을 받은 명백하고 정밀한 목표들이 육체적이든 정신적이든 불필요한 간섭없이 지속적이며 정확한 제품을 공급할 수 있습니다.

## OSH 전문가: 마지막 장......

자신들의 미래 역할을 고려하는 OSH 전문가는 고용주를 위해 완전한 독립성을 제공하는 수단으로서의 교육방향으로 기울 수 있습니다. 이와 같은 접근스타일의 교육은 질병을 앓고 있는 시스템으로부터 받치고 있는 버팀목을 제거하는 힘이 될 수 있습니다.

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## 맺음말

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# Corporate Governance – The Role of the Safety Professional

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## Introduction

Corporate Governance requires that the conventions and rules which direct the relationships between all the stakeholders ensure that the framework of structures and procedures effectively achieve growth and stability whilst maintaining the integrity of the organisation and the stakeholders. However, this definition, taken at face value may exhibit blithe ignorance of the dialectic that governs the working out of the contradictions that are inherent in the differing spheres of influence within an organisation and its social milieu. This in turn impacts upon the organisation's efficacy in creating the correct conditions for achieving growth and stability.

In the context of this congress it is appropriate to focus on the role of the safety professional in the context of the organisation's responsibility to ensure the safety of the workforce and others who are affected by its activities. The safety professional exposes some of the contradictions that pervade the issue of effective governance, in particular when, as a function of management, that role conflicts with the notion that the competent company is composed of proficient decision making employees. All too often responsibility for safety falls to the safety professional and, despite monumental efforts on his part, he is often under-resourced, under-valued and scapegoated for failure on the part of fellow managers. Here-in lies the contradiction; a dichotomisation has been created whereby safety has been separated from and transformed into an adjunct to a task where once it was an integral aspect of competent performance by each worker. As an adjunct it is susceptible to "bottom line" thinking whereby the "unnecessary" is jettisoned in the face of dwindling profitability, and held onto only to the extent that legal minimums are met. Maharaj argues that the organisation that takes the reactive problem-solving approach to safety will generally have a perception that safety issues are divorced from day-to-day business operations and are thus sub-ordinate to their demand on the time of senior management.

## Ethical Governance

The OECD Principles of Corporate Governance have established that the governance framework should recognise the rights (as qualified by law and mutual agreements) of stakeholders and encourage the active co-operation between the corporation and its stakeholders. Implicit with in this is the logical necessity that the achievement of wealth, jobs and the sustainability of financially sound enterprises will not occur without the recognition of and action upon those rights for their fulfilment. It follows from this that there is some form of ethic that underpins rational and effective governance in as much as the governing body accepts that it is right and fair to act in this way; the alternative is a too mechanistic approach to meeting these requirements that seeks solutions in fixed structures and rules.

In the UK, Boardman and Lyon have explored the moral underpinnings of corporate governance:

*Any business operates with the consent of society as a whole. Be that by adhering to specific legal constraints such as company laws, or, more broadly, due to general societal acceptance of the 'business they are in' and the trust that they will operate within generally accepted 'good business practice'. As a consequence of this, business leaders have a moral obligation not to abuse the trust placed in them by broader society".*

In this they have a preference that directors of corporations work to guidance on best OSH practices as opposed to formal legal rules that may ultimately restrain the development of best practice. Guidance contains the necessary room for creativity that is capable of recognising the contradictions that arise amongst the conflicting interests within the organization and developing innovative outworkings that will continue to achieve corporate objectives.

And universally, the OECD principles stipulate the establishment of corporate ethics that will ensure compliance with laws and standards and an oversight of all the control systems for financial reporting.

## Corporate Structure and Safety

Within the totality of stakeholders we can isolate the two primary elements responsible for the effective governance of the organisation, namely the Board and Management. The Board, accountable to the stakeholders, is responsible for the strategic direction of the organisation in the attainment of the corporate objectives, including the setting of those objectives; the what, why and how. The management is responsible for the day-to-day activities that are necessary for the setting and achievement of interim targets that go towards meeting strategic objectives; they ensure that the objectives of the company are met in a manner that is effective and non-injurious.

To achieve this it is essential that these two elements are aware of and work within their respective roles such that there is no superfluity of function that permits the one to overlap significantly with the other, thereby negating, or at best severely restricting the functionality of both.

OSH governance means that the board recognises the intrinsic right of all workers to a safe and healthy work environment and establishes the fundamental premise that the organisation will actively advance systems and procedures that ensure this right, i.e. a safe and healthy work place is not an objective to be attained in the future but a right to be exercised in the present. Thus for the company there can be only one standard of performance, namely that they produce their products and services in a manner that will not injure workers or others, and that straightforward position, extended, includes no damage to the environment or to profitability.

In the light of this, the task of management is to determine the operational outcomes, provide the necessary resources to achieve these and to periodically review the operation to consider the possibility of failure prior to commencement, during the process and at various other appropriate stages. In this regard necessary resources includes the engagement of a competent workforce well versed in the requirements of their tasks and fully authorised to make decisions is respect of the safety of themselves and others effected by their actions.

An inherent dialectic lies in a tendency for the board either to engage in the day-to-day management of the business or to ignore completely the management of the business leaving it exclusively in the hands of management undirected by corporate objectives. And where the latter is the case, a tendency may arise within management, because of their need to have a corporate direction, to create that direction and in turn to develop a desire to have greater input to corporate decision-making or by their actions on the ground, to direct the organisation in ways inconsistent with its objectives.

The mediation of these contradictions is realised in the development of distinct and separate functions for both parties whereby the Board will provide strategic guidance on management coupled with effective monitoring and oversight of internal controls; and management on the other hand will exercise its functions in a manner that supports and motivates employees to improve the level of performance in accordance with external and internal objectives (Maharaj R.)

## The Safety Professional

An effective organisation, aware of its strategic objectives, recognises and undertakes what is necessary to achieve those objectives and in a manner which is consistent with the overriding objective to produce products and services in a non-injurious fashion. There is an ongoing dialogic that requires that the participants continually reflect upon what they are doing and the reasons for doing it. It is holistic in approach and organic in its development synthesising the reflections of all into a complex whole where each person exercises necessary functions vital to the success of the business.

In this system the function of the safety professional can no longer be viewed as one who is an adjunct to management, in post to meet a perceived legal requirement or to “satisfy” in a technical sense corporate obligations to the safety of the workforce. As a “safety manager” he neuters the effectiveness of his colleagues who are charged with the management of departments, processes and other systems. Nor does he take responsibility for safety, as that is an integral element of individual and collective performance each person being himself responsible for and authorised to take decisions on matters of safety within their sphere of activity.

As a generalist advisor, he runs the risk of being superfluous in a competent company where each person is a specialist in their own vocation/profession and the sum total of safety competence dwarves the knowledge and competence of the safety generalist. Whereas as a specialist adviser he would become less of a safety professional and more of an engineer, chemist, specified operative, etc.

It is a finding of IOSH that the safety professional would in effect work himself out of a job as workers and managers become sufficiently competent and resourced. And in this, coupled with the corporate obligations of the organisation to ensure the present safety of the workforce, we find the role of the safety professional.

Reporting a death toll at some 2.2 million per annum from workplace safety and health failures at the last World Congress the ILO has produced a stark statistic that reminds us that the objectives of effective corporate governance as regards the rights of employee stakeholders to a safe and healthy work environment is along way from being achieved. While advances have been made in the ethics that should underpin governance the size of the safety profession, in particular regions, is growing and so too are the statistics (in 1999 ILO reported more than 1 million deaths).

What is required is not necessarily more safety professionals such that every company and business can employ or have access to their services; but that the profession assesses its efficacy and redefines its function and role in assisting companies achieve the levels of competency necessary to achieve non-injurious performances. In that regard the safety professional will stand apart from the board and management, apart from operational and strategic decision making, acting as an advisor on the principles of achieving a competent and effective organisation with specific regard to safety. He is a valuable adjunct to a process of change fully aware that once that process has effectively concluded the transformation his function too must necessarily change.

The principles that he will advise on are those that make possible the development of organisational competency, that facilitate the transference of necessary authority up and down the hierarchy, that release the strictures of redundant arrangements and systems that stymie the effective performance of an organisation. His function is to assist the company clarify their safety obligations, to input information where necessary to aid strategic decision making, and be part of the guidance that is available to management. He is a theoretician who can assess and identify what is required to make a company competent and how that can be achieved.

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# Development of the Competent Company in the Context of the Seoul Declaration

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## Abstract:

This paper will describe a range of techniques that will aid the development of competency within the company. It will provide tools to build appropriate structures that meet the objectives of the Seoul Declaration. Utilising exemplar models, case studies, direct experience and innovative concepts, participants will be invited to address workplace dynamics, their role within the dynamic and discuss options to aid the transformation to a competent and preventative culture.

## Introduction

The 2008 World Congress on Occupational Safety and Health at Work was hosted by the hosted by the Korean Occupational Safety and Health Agency in Seoul and commenced with a safety and health summit that included the primary organisers, the International Labour Organisation (ILO) and the International Social Security Association (ISSA), government ministers, international safety bodies, and employer and workers organisations. The summit developed and culminated in the signing of what is now known as the Seoul Declaration on Safety and health at Work, a document which will direct the work of the ILO, ISSA Governments, Employers and Employee Organisations over the next three years.[1]

In presenting the declaration to Congress a significant element that emerged from the introductory speeches by most of the key players was that the safety and health of the workforce was a human rights issue as enshrined in the UN Declaration on Human Rights. This approach impacts on everything about how we deal with health and safety at work; safety can no longer be seen as an adjunct to the work process that can be added to or subtracted from the process according to how well the bottom line is doing.

As a human rights issue it is incumbent upon governments to have in place the appropriate mechanisms for ensuring that employers are safeguarding their workforces and that any failing on their part is rapidly picked up via robust monitoring and oversight measures. This means that were there are frequent and recurrent incidents nationally that adversely affect the safety and health of the workforce there arises the possibility that the government can be charged with human rights abuses in as much as it has failed to ensure that employers exercise their responsibilities in a manner consistent with the Seoul and UN declarations. This poses interesting legal considerations regarding whether the state actually can held liable for the failings of employers within its national territory.

Nevertheless, to ensure that worker human rights are protected governments must exercise a robust inspection and enforcement regime to avoid the occurrence of any systematic failure on the part of employers. There is substance here for legal debate on the way forward, but it seems clear that the way we view and carry out our work must adapt to ensure that companies are playing their role in empowering workers through the provision of information on their rights to decent work and on prevention strategies, a key tenet of the Seoul Declaration.

Some of the presentations contextualised the role OSH professional within the contradictions afflicting globalisation and in many papers safety could not be separated from the economic climate, meaning that OSH issues are issues of total corporate governance rather than the narrower concept of OSH governance that has recently emerged within the safety profession. The OECD principles are more relevant to safety than would previously have been thought. Opening congress, Assane Diop, ILO Exec Director, stated that legislation on its own, essential though it was, was not enough and that the introduction of ILO's OSHMS:2001 was critical to the process, indeed was the defining reference with regard to bringing market systems under control and

[1] A copy of the declaration is available online at http://www.newswire.co.kr/?job=news&no=344367

protecting workers' rights. The ILO objective is Decent Work with Social Justice and in that regard the ability of all workers to participate effectively in the achievement of these objectives they need to be armed with information about their human rights, the UN Declaration on Human Rights and the Decent Work Agenda in order that they can direct and control the changes necessary for the achievement of safe and healthy workplaces. Closing the opening ceremony the Opening Ceremony Han Seung-Soo, Korean Prime Minister pointed out that as far as the economy was concerned the world was borderless and that for every workers rights to be respected and protected it was incumbent upon all countries to co-operate for worker safety. To this end the declaration outlined the following responsibilities for workers and employers;

5. Employers should ensure that

- Prevention is an integral part of their activities, as high safety and health standards at work go hand and hand with good business performance.
- Occupational safety and health management systems are established in an effective way to improve workplace safety and health.
- Workers and their representatives are consulted, trained, informed and involved in all measures related to their safety and health at work.

6. Affirming the workers' right to a safe and healthy working environment, workers should be consulted on safety and health matters and should:

- Follow safety and health instructions and procedures, including on the use of personal protective equipment.
- Participate in safety and health training and awareness-raising activities.
- Cooperate with their employer in measures related to their safety and health at work.

## The Competent Company

The concept of the competent company is one where-in the strategy, the managerial structures and polices, and the way in which the company acts to meet its responsibilities towards all the key stakeholders combine in a way that ensures the safety of its workforce and those affected by what the company does, enhances the quality of its output and satisfies the fiscal needs of the owners in a sustainable manner. Sir John Egan (1998) reporting to UK's Deputy Prime Minister on the state of the construction industry stated that;

> "*If the industry is to achieve its full potential, substantial changes in its culture and structure are also required to support improvement. The industry must provide decent and safe working conditions and improve management and supervisory skills at all levels*"

What Egan was talking about was the establishment of a competent and sustainable industry, achieved through commitment at all levels in the industry, which means that;

- Companies and their clients work in partnership within the industry, the health and safety enforcement agencies, fellow client bodies and workers and their representatives,
- Board members' commit to making safety work for all their staff and for all those affected by their work,
- Business strategies and objectives are prefaced with a commitment that goals will be achieved in a manner that does not cause harm to workers or end-users,
- Companies go beyond compliance where OSH is critical, and
- Individuals, workers and employers will act as they would expect others to act, i.e. competently.

The culture is the way in which the company holistically behaves with respect to critical factors such as safety, and the structure is the way in which it organises to itself to achieve its objectives and goals. There are two primary elements responsible for the effective governance of the organisation, namely the Board (or its equivalent) and Management. The former is accountable to the stakeholders, is responsible for the strategic direction of the company in the attainment of the corporate objectives, including the setting of those objectives. The management is responsible for the day-to-day activities that are necessary for the setting and achievement of interim targets that go towards meeting the strategic objectives; they ensure that the objectives of the company are met in a manner that is effective and non-injurious. It is essential that these two elements are aware of and work within their respective roles such that there is no superfluity of function that permits the one to overlap significantly with the other, thereby negating, or at best severely restricting the functionality of both.

## Cultural Maturity

It is not uncommon for the safety practitioner to audit the safety culture within the companies in which they are employed or engaged. Quality companies demand safe work practices and healthy conditions throughout and in order to obtain this begin with an assessment of how safety is viewed and practiced within. Often this is conducted via attitudinal surveys and supported by observations of practice. There is a tendency for this approach to admit to a high degree of subjectivity, particularly in the absence of universally accepted criteria for determining what constitutes culture and how it may be objectively measures and compared against other companies, or indeed between departments within the company.

In developing and implementing Operation Analysis and Control (OAC) processes within a company there are a number of core criteria the absence of one or more of which will severely impair the company's sustainability in times of economic crises (such as the period we are now in) and which impact negatively on its ability to remain viable relative to competitors in times of economic stability. These criteria are;

- **Corporate Social Responsibility (CSR):** wherein competent company is aware of and acts to meet its responsibilities towards all the key stakeholders, including society, customers, community, workers and owners,

- **Innovation:** the company is innovatory with the ability to diversify and transfer skills to the development of new products and outputs,
- **Resourcefulness:** the company can use existing human, material and financial resources in a creative and adaptive manner to meet the challenges of changing social and economic conditions, and
- **Authority:** the company encourages self-managing units where-in individuals and teams have the authority to make decisions within the sphere of their control and influence.

If the culture of a company is deficient in or indeed missing one or more of these criteria it runs the risk of failing to compete in the market place against competitors who are stronger in these areas or leaves itself vulnerable to prosecution for breaches of statutory duty, closed out of markets for failure to innovate and, in respect of too authoritarian an approach to management, is likely to fall foul of the declarations and conventions on safety and health at work.

For each of these criteria there are exemplar companies that have developed and implemented successful strategies that have transformed their practice with regard to safety and turned the company around in the face of economic crises.

## CSR, Innovation and Authority

Semco in Brazil turned the economic crises of the 1990s to their advantage and, re-engineering in a way unlike everyone else, were able to create new business models and work structures that took the company from near liquidation to being one of the most successful businesses in Latin America. Semler (2003) stated that;

> *"Accepting that there is no such thing as a 'special worker' perfectly suited for one company means accepting worker individuality. And once you do that, you set the stage for making the most of that individuality by encouraging workers to tap their inner reservoir and find a balance between their aspirations and the company's."*

Two things worked for Semco. Firstly after working with traditional departmentalised management structures, the company gave engineers their head and allowed them to explore and develop new product lines. This extended to setting up satellite units to develop, produce and market the products. Secondly, in the face of bankruptcy, workers and managers agreed to wage cuts in exchange for a greater share of the profits on condition that they too were given a free hand in approving every item of expenditure. This led to the workforce performing many roles compared to what they traditionally played; they became knowledgeable about all aspects of the company, including its finances; they made decisions about who to employ, what to buy in the supply chain, when to buy, who from, even what to manufacture, to what standards, and how it should be marketed. The company succeeded.

The success of the company was due to the second innovation, the recognition that the workforce are competent to receive and understand information about all aspects of the company, are competent to make the critical decisions about how the company is organised and run, are competent to make decisions about what is produced and how it is produced, and finally the competent workforce does not require, in fact may only succeed in the absence of a multi-layered hierarchy and its concomitant redundant functions.

## Authority and Resourcefulness

In 1997 the OAC methodology was first introduced to a government agency in N. Ireland with circa 2,000 employees. At the time the Agency had six Safety Advisory Officers and a Senior Safety Advisor. A widely held feeling at that time was that they were the 'safety guys', the inference being that they were responsible for ensuring safe and healthy working conditions. The changing emphasis, post 1997, was an acknowledgement that all its employees, from members of the Board to operatives out on the ground had responsibility to ensure safe and healthy working conditions, within their sphere of control and influence.

The simple, although not simplistic, approach of OAC was designed to make this transition as smooth as possible. Safety advisors were reduced in numbers and assumed a more appropriate role of providing technical assistance when requested by management and staff. Two key requirements were central to the success of this approach;

1. The Board defined their priorities as, the OSH, free movement of the travelling public and Value for Money,
2. Competence was a principal requirement for employees and contractors, (noting that competence extends to having adequate resources, responsibility to achieve and the authority to act within their sphere of control).

The effectiveness of this approach is managed through controls assurance, senior management interventions, and a robust procurement process. In order to ensure consistency the control measures were defined and provided through operational safety control sheets, linked to method statements. The key message across the organisation was that competence is an absolute and that there is a duty of care and a duty to act upon every employee from the Boardroom down.

In the first 5 years of OAC the Agency's reportable (recordable) accident levels fell by 50% from a high of 68 in 1998 to 34 for 2001. The rolling three-year average had fallen from 59.07 in 1998 to 38 in 2003. With each target met the Board set new and more challenging reportable accident reduction targets.

## Resourcefulness

Ron Greenman of Bates Technical College (Tacoma, USA) mentored an applicant with 25 years experience in industry including a number of certificates gained from courses he had taken in various colleges over that period to the bachelor's degree in Engineering Science at Thomas Edison State College (ESC). One route to the Bachelors degree in Fire Safety Engineering was the two year technical programme at Bates College. Greenman assisted his student in putting together a portfolio of evidence of prior learning and experience for submission to TESC. Though he had undertaken a programme in engineering statistics, TESC required a broader programme on general statistics which was facilitated by Bates College thus completing the portfolio and gaining the student entrance to TESC. After successfully completing his degree he went on to complete a master's degree in Fire Protection Engineering.

The goal of the project had been to suggest that given modern methods of interactive communication, institutions can offer specialized coursework and through cooperation, with one being the student's parent school akin to a middle school homeroom; multiple institutions can offer esoteric coursework without having to duplicate that coursework at each one to offer similar degrees.

This does not require that the student have a vast or any background knowledge or competency. What Greenman did was use a subject with many existing competencies to speed up the process.

Greenman and a colleague have commenced a further distance learning project with new students, in one case acting as homeroom from afar and in that other repeating the same process of no paper to bachelor's degree through competency education.

## Organisation Cultural Maturity Index (OCMI)

Having identified these criteria the task was to design a way to objectively assess how a company demonstrates that it possesses the cultural attributes essential to success in establishing preventative measures in respect of occupational safety and health. The challenge is to put in place a system that will measure and monitor an organisation's behaviour and competence and present the findings in a consistently objective manner. The Organisation Cultural Maturity Index is a tool kit that will measure the policies and practices within a company and calculate a score that will place the company on a maturity rating from 1 – 100%. The following pages outline the process.

The OCMI, once the weighting of the maturity criteria have been established, when consistently applied year on year objectively compares the growth in cultural maturity of the company. It can also be applied to specific aspects of the company (such as; OSH, Finance, Governance) or to sections of the company, e.g. to departments and similarly will allow objective comparisons between these departments.

The index table, displaying the year on year scores across all criteria for all the core capabilities of the company, provides the information necessary for the establishment of both strategic objectives and managerial targets, from which action plans may be developed.

The safety practitioner, being well versed in the prevention requirements of Seoul, ILO and national statutes, can utilise this toolkit in much the same way that they would conduct safety audits for their employer or client. Indeed for those who are competent to audit standards such as International Register of Certificated Auditors (IRCA), they may well lead the assessment team, or be a key advisor on such a team.

Moreover the OSH Professional as a safety strategist is well placed to persuade and lead the company through this process towards a growing maturity.

## The Organisation Cultural Maturity Index criteria

An organisation's cultural maturity is measured across 4 key maturity criteria;

- **Corporate Social Responsibility (CSR):** The competent company is aware of and acts to meet its responsibilities towards all its key stakeholders, including society, customers, community. Workers and owners.
- **Innovation:** The competent company is innovatory with the ability to diversify and transfer skills to the development of new products or services and outputs.
- **Resourcefulness:** The competent company can use existing human, material and financial resources in a creative and adaptive manner to meet the challenges of changing social and economic conditions.
- **Authority:** The competent company encourages self-managing units where-in individuals and teams have the authority to make decisions within the sphere of their control and influence.

## The Core Capabilities

The core capabilities are those capabilities deemed necessary by a company for the effective management of their business and successful production and delivery of products and services to their customers whilst meeting their legal and social obligations to the workforce and the public and their fiscal responsibilities to the owners of the company.

In this example 10 capabilities relating to the safety and health culture within a company have been selected for demonstrating the model. These are (in no particular order):

- Leadership
- Collaborative Working
- Working Safely
- Using Management Standards
- Developing People
- Managing Operations, Project Controls
- Reporting Effectively
- Incentivising Behaviour
- Defining Objectives
- Setting & Managing Budgets, Establishing human/material/financial resources

These capabilities will be assigned a weighting by the company in accordance with the degree of importance in achieving the company's strategic objectives or by a set of principles that is consistent and justifiable. In this example the following principles are used:

- **Weighting** in order of importance in the company:
  - Legal requirement = 10
  - Strategic objective = 8
  - Managerial requirement = 5
  - Operation necessity = 5

The core capabilities are then measured against the each of the maturity criteria utilising a set of questions designed to elicit information from a representative selection of senior staff and employees, and to gather material evidence that will substantiate the assessment conclusions.

The questions are based around an agreed set of indicators that will demonstrate whether the company or a particular department has the essential knowledge and competence in respect of each of the maturity criteria. For example the indicators in respect of the core capabilities of Leadership, Collaborative Working and Working Safely may be:

| | CSR | Innovatory | Resourcefulness | Authority |
|---|---|---|---|---|
| **Leadership** | There is evidence that the OECD Principles are being applied. | There is evidence that the company is guided by ILO OSHMS, 3.10.2 when embracing change. | There is evidence that the company is using the competence of its workforce to deliver its outputs. | Determine from the available evidence what management style the company adopts; (Authoritarian to democratic). |
| **Collaborative Working** | There is evidence of worker participation is safety decisions. | There is evidence that teams are encouraged to innovate. | There is evidence of the team's ability to identify and acquire resources. | Determine the decision making powers of the teams (Complete authority through to no authority). |
| **Working Safely** | Determine what the drivers of the company's strategy and policy are. | There is evidence of the company's ability to develop new solutions & improve existing controls to ensure work progresses safely | Determine to what degree the requirements to make work safe are available. | Determine who the decision makers on the safety of an operation are. |

Assigning a score to the information and evidence gathered is based on an objective determination of the knowledge held and ability to act on and manage the operation or procedure of the people within company or the department that is being assessed. The determination of the assessor must be reasonable and in line with what another person competent to conduct such an analysis would make– i.e. the judgement of the evidence and the scores assigned must not be perverse.

The assessor and the assessment team would be guided by standard audit practices and methodologies. This would ensure the objectivity of the process and permit independent (second or third party) verification of the evidence and scoring.

The following table illustrates the scoring range.

| Basis for scoring | No evidence | Awareness | Knowledge | Understanding | Ability- competent to act | Ability – competent to manage |
|---|---|---|---|---|---|---|
| Scoring Range | -1 | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 |

- **No Evidence,** where no evidence is produced or the evidence produced is insufficient or unsuitable the score assigned is -1. There is no need for a range of negative scores as absence is an absolute in the context of this assessment.
- **Awareness,** individuals and teams, the department or the company demonstrate awareness of policies and procedures or of the primary indicators pertaining to the core capabilities but have not been able to demonstrate knowledge of the content or detail. Score 1-2
- **Knowledge,** the content and detail of the primary indicators are adequately known to a sufficient number of managers and workers such that they can carry out their functions or follow the guidance contained within them. Score 3-4
- **Understanding,** a sufficient number of managers and workers demonstrated an understanding of the purposes and requirements of the policies or of the how and what of their work activities such that they can explain then to another. Score 5-6
- **Ability – competent to act,** a level of understanding has been achieved such that a sufficient number of managers and workers can carry out their work activities safely and unsupervised. They are capable of anticipating and reacting to variations in the work conditions. Score 7-8
- **Ability – competent to manage,** a level of ability such that they can consistently manage the processes at work, and others, are capable of interpreting the requests from above, determining the requirements for and authorised to obtain the resources and direct work operations. Score 9-10

The scoring range permits the assessor to exercise his professional judgement as to the extent that the evidence demonstrates the level.

It is useful for the assessor to make a note of his findings following discussion with individuals, or his examination of documentation and of any observations that he makes. The following is an example of a record of findings. Remember to keep a list of all those interviewed during this process, but avoid attributing specific comments to individuals. OCMI is about the company not the individual and gaining and maintaining the trust of individuals within the company is vital.

| Assessor record of findings | | | |
|---|---|---|---|
| **Question Set** | **Discussion with Top tier management / Management / Worker** | **Documentation** | **Observed Practice** |
| | *Note the key findings of discussions with a representative sample of ...* | *Note is available and what they say about...*<br>*Policy statements*<br>*Boards Minutes*<br>*Strategy workshops*<br>*Annual reports* | *Sit in on Board meetings, strategy workshops, and safety committees. Walk about shop floor, offices and other departments* |
| **An example of Leadership assessment relevant to Corporate Social Responsibility** | | | |
| Is there a director with board responsibility for OSH? | | | |
| Is the OSH impact of all safety decisions considered before the strategy is developed? | | | |
| Are safety duties and responsibilities considered and communicated to all? | | | |
| Do the President and VPs lead by example? | | | |

After having conducted his discussions with management and workers, reviewed the documentation and noted any matters of significance in his observed practices the assessor is then in a position to assess the findings and arrive at his conclusions with respect to scoring. This process continues through all the agreed capabilities and across all four maturity criteria until the assessor is satisfied that he has obtained sufficient information to complete his overall assessment. The scores he has obtained are then inserted into the final matrix and calculations carried out in order that will result in a percentage achievement in the organisations cultural maturity, in this example in respect of the safety culture.

Maturity criteria for a competent company

| Core Capabilities *(In respect of Safety Culture)* | CSR | Innovation | Resourcefulness | Authority | Score Avg. =Sum(b:e)[2] | Weighted multiplier | Multiplied score |
|---|---|---|---|---|---|---|---|
| **Leadership** | SCORE 1- 10 | SCORE 1- 10 | SCORE 1- 10 | SCORE 1-10 | AVERAGE SCORE | Weighting number between 1 & 10 | AVERAGE x MULTIPLIER |
| **Collaborative Working** | REPEAT | REPEAT | REPEAT | REPEAT | REPEAT | REPEAT | REPEAT |
| **Working Safely** | REPEAT | | | | | | |
| **Using Management Standards** | REPEAT | | | | | | |
| **Developing People** | REPEAT | | | | | | |
| **Managing Operations, Project Controls** | REPEAT | | | | | | |
| **Reporting Effectively** | REPEAT | | | | | | |
| **Incentivising Behaviour** | REPEAT | | | | | | |
| **Defining Objectives** | REPEAT | | | | | | |
| **Setting & Managing Budgets, Establishing human/material/financial resources** | REPEAT | | | | | | |
| | | | | | *Totals* | ***TOTAL ABOVE*** | ***TOTAL ABOVE*** |
| | | | | | **Maturity Rating** | | **CALCULATION of %age** |

[2] That the average of sum of the scores in column b (CSR) through to column e (Authority)

## The calculation

- The scores in respect of the 4 maturity criteria are averaged out for each core capability.
- They are then multiplied by the agreed weighting.
- The total of the weighting numbers are added.
- The total of the multiplied scores are also added.
- The calculation of the percentage maturity score is obtained by using the following formula:

$$\frac{\text{Total multiplied score}}{\text{Total of weightings x 10}} \text{ x } 100 = \%$$

The following table illustrates a worked example for the Cultural Maturity of a company with specific reference to OSH.

The following Core capabilities examples relate to the evaluation of the safety culture in a company. The scores inserted are by way of example.

Company Name: Company Contact Details:

Maturity criteria for a competent company

| Core Capabilities *(In respect of Safety Culture)* | CSR | Innovation | Resourcefulness | Authority | Score Avg. =Sum(b:e)[3] | Weighted multiplier | Multiplied score |
|---|---|---|---|---|---|---|---|
| **Leadership** | 6 | 8 | 4 | -1 | 4.25 | 10 | 42.5 |
| **Collaborative Working** | 3 | 6 | 5 | 9 | 5.75 | 5 | 28.75 |
| **Working Safely** | 6 | 3 | 2 | 8 | 4.75 | 10 | 47.5 |
| **Using Management Standards** | 5 | 6 | 7 | 8 | 6.5 | 5 | 32.5 |
| **Developing People** | 8 | 7 | 6 | 5 | 6.5 | 8 | 52 |
| **Managing Operations, Project Controls** | 3 | 2 | 8 | 8 | 5.25 | 5 | 26.25 |
| **Reporting Effectively** | 6 | 7 | 8 | 5 | 6.5 | 10 | 65 |
| **Incentivising Behaviour** | 7 | 3 | 2 | 8 | 5 | 5 | 25 |
| **Defining Objectives** | 8 | 6 | 7 | 8 | 7.25 | 8 | 58 |
| **Setting & Managing Budgets, Establishing human/material/financial resources** | 5 | 7 | 6 | 5 | 5.75 | 5 | 28.75 |
| | | | | | *Totals* | *71* | *406.25* |
| | | | | | Maturity Rating | | 57.22 % |

This company has an OCMI rating of 57.22 for Safety Culture.

[3] That the average of sum of the scores in column b (CSR) through to column e (Authority)

## Initial set-up and Training

| Stages to Implementation | Training & Support Element | Notes |
|---|---|---|
| Stage 1 – Train up the OCMI Team | Strategy team – Senior management and safety professionals | Establishing core capabilities, indicators and weightings |
| | Implementation team - will include safety practitioners, business unit managers, volunteers from the workforce | Evidence gathering, questioning techniques, powers of observation, assigning values. Developing the manual for this process |
| | All | Appropriate support from strategy team throughout the training and baseline audit phases |
| Stage 2 – Establish question sets pertinent to the 10 capabilities | Implementation team | The will lead to the development of an OCMI manual |
| Stage 3 – Conduct a baseline audit across an agree number of business units | Strategy team | Terms of the baseline audit, set and agree maturity rating etc.<br>Select target business units to be assessed with a control unit identified |
| | Implementation team | Conduct baseline audit under auspices of lead-auditor |
| Stage 4 – Analyse the results and agree the baseline | Strategy team | Evaluation of the results and the overall process |
| Stage 5 – Establish the Maturity Rating targets for all business units and the company * | Strategy team | |
| Stage 6 – Agree action plans for each business unit | Business managers/Heads of units and auditor | Exclude control unit from development of action plans |
| Stage 7 – Implement action plans | Business managers/Heads of units | |
| Stage 8 – Conduct second OCMI audit ** | Strategy team and Implementation team | Compare target units with control unit to assess the impact of the approach |

The process is continuous

* e.g. "All business units must increase their rating by x%. Business units below the baseline must achieve the baseline as a minimum.

** A new baseline to be established at higher than the previous one.

- At the end of the initial training and support element the company will have a fully developed OCMI manual incorporating the company's OCMI rating pro-formas all ready for use.
- OCMI uses the individual observations/ discussions of the audit to determine the overall cultural maturity of the organization, focusing on governance, innovation, resourcefulness and authority.
- This approach. With modifications to suit the particular company, assists in the development of a business case for submission to the Board of the company.

# An Exploration of Structured and Flexible Approaches to Recognising Engineering Competence

## CONTEXT

Construction industry deaths and injuries are amongst the highest despite considerable efforts from legislators and practitioners to improve safety. In 2005–06 thirty-nine employees per day sustained a serious work-related injury or disease. The link between construction site accidents and designers is not always obvious at the point and place of an accident.

## KEY MESSAGES

A key theme, within construction-related professional code of ethics is that designers make the best use of resources in the care of the environment and in the best interests of OHS. Each designer brings their own unique skill and personality to every situation in which they function.

## OBJECTIVES

The question is how can designers' competence be developed and used in a meaningful and beneficial way to ensure delivery of the objective that;

"Designs should be such that they can be built, used, maintained and eventually demolished safely"

Since that responsibility lies initially and primarily with designers the aspiring engineer's journey to independence of thought and action requires the provision of practical information about safe design principles.

## CONCLUSION

The Quebec Protocol (2003) defined "*the principles and measures ... designed to integrate occupational health and safety into vocational and technical education*" and the National OHS Strategy 2002–2012 concurs.

Therefore it is for educators to assist students comprehend the importance of designing safe products, buildings, processes and systems. This paper, using international examples, explores the integration of structured and flexible approaches leading to recognition of the competence of professional engineers, concentrating specifically on essential OHS attributes.

# An Exploration of Structured and Flexible Approaches to Recognising Engineering Competence

## INTRODUCTION

> "For the things we have to learn before we can do them, we learn by doing them."
> Aristotle, *Nichomachean Ethics*

"The role of engineering in [...] society is much greater than is generally believed. It comprises not only those who call themselves engineers or are entitled to this functional name but all those who practise engineering in the course of their professional activities and may include some who do not identify themselves with engineering" (FEANI, 2005).

What is it that makes someone an Engineer? Is it their academic and professional qualifications or is it the competence that they are able to demonstrate? Maybe this is a false dichotomy, that it is neither one nor the other but rather a combination of both qualification and competence. The truth of this can be tested with a few questions and an assessment of the validity of the responses. For instance does the holding of a degree in engineering confer on the graduate the status of engineer?

At first glance it would appear that the answer is yes, of course, and that is how the graduate would like to be considered. At this point of their career they have taken the first step and are on the engineer's development curve, and it may well be that over a long and successful career the starting point of being an engineer would be the date of their graduation. But if in the days after their graduation they moved into a totally different career path without ever having practiced as an engineer, it would be irrational to state that they became an engineer on the date of their graduation. What could be said is that they possess an engineering degree; that they have some knowledge of engineering. However there is more to it than that. The UK Joint Board of Moderators (JBM)[1] determined that graduate engineers must demonstrate attitude, knowledge and a degree of competence particularly with reference to health and safety (JBM, 2005).

**Table 1: Attributes for Corporate Membership of ICE**

At Chartered Professional Review candidates for corporate membership of the Institution of Civil Engineers (ICE), Chartered Engineer (CEng) are required to demonstrate that they;

- Understand their personal responsibilities relating to Health, Safety and Welfare.
- Have a sound and up to date knowledge over the range of legislation relating to the construction industry and general construction-related hazards.
- Have detailed knowledge of the hazards applicable to their particular field of work
- Understand the social and economic benefits of good safety practice.
- Can apply risk management techniques.
- As a designer, they can apply the risk hierarchy to designs and interface with other statutory duty holders.
- On site, they can deal with people issues and interfaces to ensure a safe place of work using best practice solutions.
- Understand the need for a continuing acquisition of knowledge to drive higher standards of safety throughout the industry.

Thus the academic qualification in and of itself does not confer being, but is an important certificate of knowledge acquisition, to be held in order to pursue higher qualifications and an engineering career. Can the same be said of professional qualifications, i.e. chartered or licensed professional engineer?

## IF NOT QUALIFICATION...

Professional qualifications differ fundamentally from academic qualifications in that they are awarded after a period of practice (normally mentored) during which the candidate undertakes professional development programmes in the context of engineering practice and will satisfy a panel of experts that he holds and is able to apply his knowledge at or above defined minimum competence standards. Often, but not always, the academic qualification is a prerequisite.

[1] JBM is the body that sets the educational standards for accredited civil related engineering degrees, which are officially recognised by the professional institutions as providing the requisite educational base for graduate engineers.

Furthermore, it is a requirement of the professional body that the aspirants to and holders of their qualification are practising within their standards as engineers. Thus to hold the professional qualification is to be an engineer. However the professional qualification did not confer the status of engineer but rather it conferred recognition after the fact and this is illustrated by the reality that there is no specific obligation on the engineer to seek the professional qualification[2]. Qualification therefore is not a necessary element to the definition of what makes an engineer, though this is not to underplay its importance in both facilitating the route towards and recognition of competence.

If not qualification, what then?

What is emerging in the analysis of qualification is that what makes an engineer is the condition of being an engineer, implying the act of doing engineering. However it seems less than sensible to suggest that by the mere fact of doing something, one can lay claim to the status of being an engineer. Members of a team building course who throw a plank across a stream are to a degree applying science to the problem of crossing the water, and successfully so, but it would be incorrect to call them engineers and even though they may be continually doing that or similar activities, the most that could be said is that they are demonstrating a propensity for engineering. Something more is required.

## DEFINITIONS

Engineering has been defined "the application of science to the optimum conversion of the resources of nature to the uses of humankind", (Encyclopaedia Britannica) and "the creative application of scientific principles to design [etc]...as respects an intended function, economics of operation and safety to life and property", (Engineers Council for Professional Development, USA[3]). In being an application it is an activity and by extension engineers are those who are actively engaged in said application.

Florida State defines engineering design as meaning "the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective...". Indeed the American Society of Civil Engineers (1994) states that "...[t]he sole purpose of state statutes requiring professional licensing of engineers is to protect the health, safety, and welfare of the public by identifying individuals that have met certain education, experience, and competence standards for licensing and have agreed to the ethical practice of their profession...". In this we again see the requirement for health and safety to be a core component of engineering competence. The UK Standard for Professional Engineering Competence (UK SPECS)[4] rather than defining it refers to professional engineering as a mindset and a way of life. Engineers they claim use judgement and experience to solve problems when the limits of scientific and mathematical knowledge are evident. Thus truly inspired professional engineers push the limits of knowledge further and / or apply more fundamental knowledge and skills in new and creative ways. Dauphin 2002[5], argues that "competency is individual in nature", meaning, in this context that "each engineer "brings unique skills and personality characteristics to every situation in which they functions". For example in 1984, in response from a call from NASA for housing designs for construction on the moon and Mars Iranian architect Nader Khalili developed the Superadobe construction method, which in recent times proved an excellent temporary solution in the aftermath of the Asian Tsunami (2004).

Also within the definitions of what is to be applied there is contained the ends to be achieved. The former holds within it the requirements of knowledge and practical ability and the latter the means whereby the competence of the actor may be determined and thus the status of being

2 This is an argument in logic that is not negated by any legal requirement to hold a professional practice qualification.

3 Now Accreditation Board for Engineering and Technology

4 Published by the Engineering Council UK on behalf of the United Kingdom's major professional institutions. It primary task is to set the standards for registration as a professional engineer and to maintain the register of engineers.

5 Barry Dauphin, PhD, Professor of Psychology at University of Detroit Mercy, *Letter on Competency for Psychologists*; in response to the request from the Department of Community Health that psychologists answer six questions about competency in our field.

or not being an engineer. Mertens (1996)[6] distinguishes between qualification and competency in that the former "is a group of knowledge and capacities that individuals acquire during socialisation and training processes", where-as "competency refers only to certain aspects of the store of knowledge and abilities: the ones necessary to achieve certain results demanded by a specific circumstance; the actual capacity to achieve an objective or result in a given context".

Though there are many definitions of competence, ultimately it is in the nature and the quality of the output that determines the degree of competence of an individual, and in that respect what makes an engineer is determined by both what he does and what he produces. Incrementally, the individual who is not an engineer becomes so by the acquisition of sufficient quanta of learning and experience until qualitatively what he does may be called engineering and he may be sensibly termed an engineer. Dawkins (1993)[7] stated that "[t]he competent mind is continuous, that is it sees connections, develops solutions and it makes decisions", and the competent engineer, freed from dependency on the oversight of others continues through self-management to a point where he is competent to become competent, that is he has reached the point, akin to the pioneers of engineering, where he has the knowledge, experience and skills to make and re-make himself; not so much accepting his limits, rather recognising that his ability to transfer his skills allows him to continually expand his knowledge and competence.

It is here that we turn to the processes, both structured and informal that contribute to the acquisition of engineering competence.

## STRUCTURED AND FLEXIBLE APPROACHES

> Learning is "...the result of unhampered participation in a meaningful setting". Ivan Illich, *Deschooling Society, 1971*

The difference between structured and flexible approaches to engineering competence is not so much that the former takes place within a more ordered environment than the latter, rather that it takes place within formal institutional parameters; the initial phase of which is bounded by set curricula with progress regulated by examinations, while the latter, although often utilising formal programmes of study, is constructed by the learner to meet his personal requirements rather than those of an institution. Despite the fact that his progress is less formally regulated and his career opportunities may be limited by statutory licensing requirements or inability to meet minimum academic and professional criteria his personal development is nevertheless equally as valid therefore, subject to him being capable of demonstrating the consistent application of the accepted standards of competence the barriers should, or rather must come down.

The route that an individual chooses may be determined by the success or otherwise at examinations at the end of his school years, as well as any economic and opportunity factors that prevail. Many do not meet the criteria for university at this stage and their future success in the field of engineering is very limited. The formal route is both desired by the student, and more accepted by the professions and by society to the detriment of those who would choose or are driven towards alternative routes. Though it has been shown that the development of competence is not dependent upon either route to the exclusion of the other, the fact that the formal is prevalent is as much to do with perceptions of this route as it is to do with its efficacy.

Since the responsibility to ensure that designs are capable of being built, used, maintained and eventually demolished safely lies initially and primarily with designers the aspiring engineer's journey to independence of thought and action requires the acquisition of information about safe design principles. It is for educators to assist their students comprehend the importance of designing safe products, buildings, processes and systems as they embark upon their unique and individual journey towards engineering competence[8]. McAleenan & McAleenan (2007,

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[6] Mertens, Leonard, Competencia Laboral: sistemas, surgimiento y modelos, Montevideo, Cinterfor/ILO, 1996, referenced in 40 Questions on Labour Competences (ILO 2004)

[7] Excerpted from *The Great Ape Project*, edited by Paola Cavalieri and Peter Singer London: Fourth Estate, 1993.

[8] The Australian Safety and Compensation Council (ASSC), produced safe design guidance as an educational resource for engineering students in March 2006, with the vision to have a Safe Design focus incorporated into a wide range of undergraduate subjects. The Joint Board for Moderators (UK) in September 2005 published standards for health and safety teaching in accredited

2008) refer to a unique journey to independence, arguing that the life experiences gained from birth onwards shape the person we become and every experience is part of the learning process. The belief being that education is a life-long process and that structured portions along the way, i.e. college degrees, are often incubators built for specific purposes. Who determines the degree content and stipulates the pre-requisites to progress, while doing so with best intentions needs to be aware of the potential to nullify the equally legitimate non-structured educational forms. Greenman (2009)[9] asked who should the decision makers of society's canon be and fundamentally whether such a canon should even exist. The answer to this, when applied narrowly to engineering, may open up greater possibilities for aspiring engineers.

Illich (1971) ascribes the adherence to structured learning to the myth that process, in this case schooling produces something of value and production necessarily produces demand. The demand for formal education tends to direct personal and social activities to take the shape of client relationships to other specialised institutions, hence the success and authority of universities and professional bodies to largely determine how success is measured in specialised careers. His view is that the self taught individual, or those engaged in nonprofessional activity are discredited, not by their failings but by the strength of the perception that more formal education means more value and that the value of this learning experience is measured and graded by exams, certificates and professional qualifications, all of which reinforces the separation between those with and without them. This is not an absolute and it only holds its position as long as the premise is universally accepted that formal learning produces something of value that in turn institutionalises the process. This is not the case.

**Case Study**

Ron Greenman of Bates Technical College (Tacoma, USA) mentored an applicant with 25 years experience in industry including a number of certificates gained from courses he had taken in various colleges over that period to the bachelor's degree in Engineering Science at Thomas Edison State College (ESC). One route to the Bachelors degree in Fire Safety Engineering was the two year technical programme at Bates College. Greenman assisted his student in putting together a portfolio of evidence of prior learning and experience for submission to TESC. Though he had undertaken a programme in engineering statistics, TESC required a broader programme on general statistics which was facilitated by Bates College thus completing the portfolio and gaining the student entrance to TESC. After successfully completing his degree he went on to complete a masters degree in Fire Protection Engineering.

The goal of the project had been to suggest that given modern methods of interactive communication, institutions can offer specialized coursework and through cooperation, with one being the student's parent school akin to a middle school homeroom, multiple institutions can offer esoteric coursework without having to duplicate that coursework at each one to offer similar degrees.

This does not require that the student have a vast or any background knowledge or competency. What Greenman did was use a subject with many existing competencies to speed up the process.

Greenman and a colleague have commenced a further distance learning project with new students, in one case acting as homeroom from afar and in that other repeating the same process of no paper to bachelors degree through competency education.

The structuring of engineering programmes is not self-initiating but stems from the tendency to formalise the process of passing on any human experience worthy of transmission to the next generation. Engineers such as Telford and Smeaton[10], who began their working lives in careers

engineering degree programmes and all of this falls in line with the Quebec City Protocol (October 2003) for the integration of occupational health and safety competencies into vocational and technical education, recognised by recognised by international organisations like the United Nations (UN), the United Nations Educational and Scientific and Cultural Organisation (UNESCO), the World health Organisation (WHO), the International Labour Office (ILO) and the International Social Security Association (ISSA) . In particular the Quebec Protocol that H&S competencies associated with each step of in the performance of a task must be integrated into the educational process. With all of this there is substantial evidence that health and safety competencies are required by law, standards or protocols to be integrated into professional development.

[9] In private correspondence with the authors.

[10] John Smeaton (1724-1792) started educational life studying law, he left this behind to become a scientific instrument maker and from there he developed an interest in mechanical engineering before practising what is now largely known as civil engineering. Thomas Telford grew up as a farm hand herding sheep and cattle before starting out as an apprentice stone mason at age of 14. He was a prolific self-educator who became a surveyor of public works by the age of 30 were he gained a reputation in both engineering and architecture in a short space of time. Octave Chanute (1832-1910) at age 17 with no formal engineering education offered his services for free to Hudson River Railroad, New York, where he spent 4 years working his way to Division Engineer, before moving west to Chicago to become chief engineer. In later life he focussed on the study of flight. He was a prolific writer, past president of the American Society of Civil Engineers. There are many other examples of society's great engineers starting their careers with a variety of educational and academic backgrounds.

other than engineering were pioneers who often learned "on the job" developing the profession bit by bit through their mistakes and their successes, (this favours the case for flexible or informal routes to engineering). Succeeding generations would skip the purely experiential route in favour of a taught programme supplemented with supported/mentored experience, the rationale being that if the pioneers pass on their valuable knowledge the next generation would more quickly attain the status of engineers and be into safe and healthy quality practices all the sooner, (the case for formal route). Very rapidly structured programmes of learning, supported by case studies of would become the norm and accepted as a reliable way to becoming an engineer, fully cognisant of the design and quality issues and as judged by his peers, competent to practice.

The advantages of the structured approach lie in the fact that standards of engineering practice, based on what works and what hasn't have been compiled, graduated and inform the stages of competence development. Such standards have been globalised and mutual recognition of degree programmes and professional qualifications are now established through the Washington, Sydney and Dublin Accords. The Australian National Professional Engineers Register (NPER) states "Registered Professional Engineers can be expected to comprehend complexity and function independently...while achieving desired outcomes within the context of a safe and sustainable environment".

Without a doubt the message is that those who hold these formal qualifications have already proved themselves capable of undertaking engineering at a high level. From the perspective of an employer or client those who hold recognised degree and professional qualifications are well placed to succeed since professional certification, supported by continuing professional development, act as a reliable third party verification of competence. Those who take an informal route absent the certification have a difficult task proving their competence.

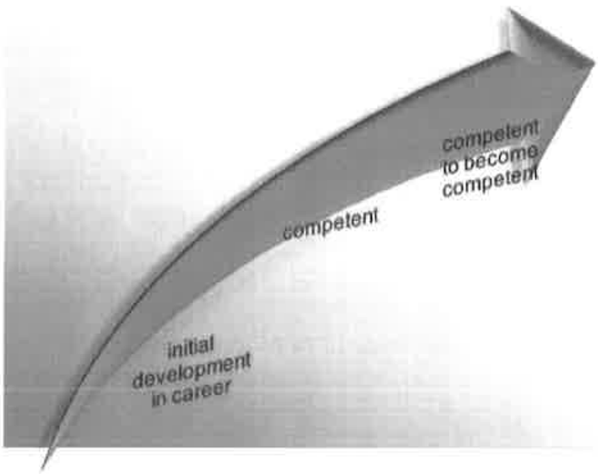


Figure1. Competency Development – Going Beyond Competence

The interaction between the student engineer and the environment creates change within the learner who in turn changes the environment, of which he is a part. This also in turn brings about the situation wherein the student incrementally changes until a point is reached when he is no longer a student but an individual who stands in contradiction to what he was independently able to decide and control the changes he makes on the environment, i.e. he becomes the engineer he wants to be.

But the individual as an engineer stands continuously as a contradiction in and off himself, both competent and not-competent at the same time[11]. He may remain at that point, sufficiently competent to maintain his status quo, or he may chose to progress, broadening his experiences and acting on ever increasing challenges until he reaches a point of excellence, a

Jacob Linville studied as a lawyer and switched to surveying then bridge building, referred to by his peers as one of the giants of 19th century bridge-building in USA. John Stevens, chief engineer on the Panama Canal was educated as a teacher and without technical training embarked upon an engineering career in the railroads of Canada and USA. One of Octave Chanute's mentees George Morison was educated in law and called to the bar in 1866, before giving it all up and starting a civil engineering career in 1867, rising to the heights of President of the ASCE (Source http://content.asce.org/history/).

[11] For an explanation of this dialectic refer to Hegel, Kant, Marx and Engels.

point where is he able to become competent in different and wider areas, he is competent to become competent; capable of continuously extending the boundaries of his knowledge.

Clearly there is merit in accepting both the structured and the flexible route as valid, recognising that people grow and develop at different rates. Not every student is ready for third level education at 18 years old. There are those who embark upon practical work, sometimes in the construction field and sometimes in other areas, indeed much like the early pioneers there are those who study and practice seemingly unrelated professions in their early career years, only become involved in engineering at a much later stage in their development, bringing with them novel perspectives to the challenges of engineering. As an industry the engineering professions need to be aware of and sympathetic to such situations, afterall engineers from diverse backgrounds can only serve to enhance our collective knowledge. The flexible route is acknowledged by Engineers Australia and ICE which affords the non-traditional candidate the opportunity to present their credentials to and have their flexible education and development recognised alongside their structure-developed colleagues.

The tenet of this paper is not to dismiss one form of development in favour of the other, nor is it dismissing formal professional qualifications. Rather it argues that professional qualification is a measure of competence, based on life and work experiences, knowledge, skills, attitude, ability to innovate, resourcefulness and authority. That all or at least most of these attributes are seen as achievable by both degree candidates and mature, flexibly developed individuals is a measure of the confidence the profession has in its peer review process.

## HIGHER STANDARDS AND COMPETENCIES IN OHS

Engineers Australia recognise that competency is a measure of ability, regardless of how that ability has been acquired, however this recognition comes with the caveat that this is valid only if we understand in depth what constitutes dependable performance and dependable performance includes designing and building structures in a safe and healthy manner. Similar sentiments are expressed in the ICE technical routes to chartered status, together with the warning to those that think that flexible approaches are an easy option and a "cop out" for the Institution that the rigours of the approach will thoroughly test the candidate, including as it does an academic[12] and a professional review in addition to the production of an evidence-focused technical report. Candidates, following the flexible route are warned of this at the outset and are well advised to have a mentor to guide them through the process.

Since either of the routes; structured or flexible, are recognised and legitimate in many countries it comes down to choice of the individual and the pace of their personal development, often driven by circumstances, but clearly the desire is to have either route officially recognised though professional qualification. Is there room for the engineer who meets all the competency standards and through choice determines not to seek professional qualification? Why should he not be acknowledged as capable of contributing to the body of engineering knowledge? While it presents a high degree of inconvenience for the individual concerned this is, perhaps, more of a dilemma for the client or employer, who seeks to establish whether the non-professionally qualified engineer holds all of the requisite competences to deliver a safe product. Such individual choices must not be written off as maverick and unsustainable, since in doing so an excellent thinker, designer, strategist may easily be discarded and the engineering world would be all the poorer for it. The existence, therefore of protected titles such as chartered engineer or licensed professional engineer adds substantial weight to the credibility of the holder and the transferability of his professional qualification to other jurisdictions and presents security and comfort to clients and employers, but they have yet to be universally accepted.

How much more does the conferring of higher awards such as "Fellow" enhance the status of the individual and of the institutions within whose gift such awards lie? Fellowship awards do two things, firstly they recognise and honour exceptional achievement or contribution to the profession and secondly they may be awarded to anyone, irrespective of whether they are a member of the profession, who makes such a contribution. ICE may award those who are

[12] The academic review is to allow the reviewer the opportunity to test how a candidates experience compensates for the shortfall in academic achievement, when compared with candidates whose educational base derives from the holding of an accredited degree.

engaged in a position of responsibility for important engineering works, who have a high reputation in the field, who have made a significant contribution to engineering achievement, or "who by virtue of their position have been able to make a positive impact on the civil engineering or associated profession, *whether or not they are engaged in the practice of the profession* [our emphasis]". Ordinary recognition is achieved by meeting the standards established, but the higher level requires that the recipient has gone above and beyond what is ordinarily required of an engineer. In this regard the door is open to all who are in or are associated with engineering to be recognised for excellence. It is a driver for the engineer not to rest on his laurels, nor to rest his competence level at a point that merely satisfies social and economic needs but to continue to see potential and creatively respond to it. It recognises contributions across a broad range of activities including management of major projects, the development of vision and strategies, marketing and promoting the profession, and demonstrating the importance of engineering to society. The range and breadth of criteria are more than sufficient to encompass the activities of engineers who by whatever route are in or associated with the profession.

One such area is in respect of health and safety and requires of the Fellow that he appreciates and manages the risks that arise as a consequence of his actions. It says much that this is a qualifying criterion for a higher award, rather than one that should be adjudged integral to the practice of engineering at all levels. At graduate level there is an insufficient awareness of the OHS issues associated with work in the field, though this comes with experience. It may well be that the future will recognise that health and safety is a core competency and that the current classification of it as a criterion for excellence is a recognition of its past absence from structured programmes. Certainly the Quebec Protocol (2003), has established principles for the integration of OHS competencies into the education programmes for all occupations, thus what is now regarded as exemplary will in time become the norm.

ICE is in the process of increasing the profile of health, safety and welfare (HSW) within the industry among professionally qualified engineers. This they have done through the introduction of the Construction Health, Safety and Welfare Register. Register Members are professionally qualified, have built on their HSW competence level (above that demanded at the Chartered Professional Review), have been peer reviewed, and have met the additional attribute standards. They have demonstrated that they have sound knowledge of scientific, engineering and technical principles, experience of construction processes and knowledge that extends to future use, maintenance and demolition. This route is open only to any chartered professional engineer and is not restricted to ICE members.

## CONCLUSION

For the engineer it should not simply be a matter of developing an awareness of and practicing safety when on site, but also of recognising the health and safety implications of his designs, of getting to grips with how the design will impact on the health and safety of the construction workers, of the public who will use the completed structure, the maintenance workers who will keep it in good order throughout its life and at some point in the future the workforce who will be required to demolish it. There is nothing new in the idea that those who design and construct a building should be held accountable for any failings in their design that leads to injury to another, but lawmakers are developing regulations that are not about supporting this as established practice, but are about compelling designers to adopt the practice.

From what we have seen the professional bodies across the globe are taking on board this requirement, though too often it is viewed as a mark of excellence rather than a core competency. For this to change the way forward lies with complimentary action between Government strategies and the policies that professional bodies adopt for membership e.g. in the National OHS Strategy the priority is to integrate OHS 'safe design' competencies into professional training. Developed before the Quebec Protocol, this strategy is in keeping with what ISSA has declared as a guiding principle, namely that safety and health are integral rather than an adjunct to competency.

In moving safety in design to the appropriate level of competency development, engineers, whether following a structured or flexible route, will be cognisant of their responsibilities and be making a significant contribution to the development of safe construction and reduction of accidents on site and throughout the lifetime of their structures. Prevention is the goal established at the World Congress of OSH in Korea (2008) and it is the responsibility of all the partners in the construction process, government, client, contractor and engineer to make this happen.

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# An Exploration of Structured and Flexible Approaches to Developing OSH Competence in Engineering

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## Abstract

How can designers' competence be developed and used in a meaningful and beneficial way to ensure the development of inherently safe(r) designs and the delivery of the objective that designs should be such that they can be built, used, maintained and eventually demolished safely. Since that responsibility lies initially and primarily with designers the aspiring engineer's journey to independence of thought and action requires the provision of practical information about safe design principles. The Québec Protocol (2003) placed an onus on educational bodies and the institutions responsible for the prevention of industrial accidents and occupational diseases to ensure that OSH is incorporated into the educational processes of all occupations, that mastery of the requisite Occupational Safety and Health (OSH) knowledge and practice are a focus of evaluation and that the education bodies adopt exemplar OSH practices as well as polices and rules. Students develop their competence through active participation in a variety of learning settings, both formal and informal, therefore it is for educators and mentors to assist students comprehend the importance of designing safe products, buildings, processes and systems. This paper, using international examples, explores the integration of structured and flexible approaches leading to recognition of the competence of professional engineers, concentrating specifically on essential OSH attributes.

## Key words

Structured & flexible education, Occupational safety & health, Québec protocol.

## Introduction

The authors have long held that occupational safety and health (OSH) is an integral element of the competencies of both vocational and technical work practices rather than an adjunct to them that is to be determined and managed by safety professionals, (McAleenan & McAleenan 2002). Making the case to the Global Forum for Prevention at the XVII World Congress on OSH (2005) that the competence of operational staff and thus their effectiveness is compromised by the intervention of safety officers into the management of their activities thereby negating the practice of universal responsibility for prevention, (McAleenan & McAleenan 2005).

The case for OSH competencies being a reasonable expectation of a competent worker was illustrated in the case of Dalton v Frendo (Irish Supreme Court 1977, discussed in pps. 69-74, Garavan 1997) where the age, experience and skill of the workman was considered integral to the employer's duty to take reasonable care of his employees' safety. The duty of care requires the appointment of competent staff and that competence includes what ought to be known about the hazards, risks and controls of the work activity.

The 1970s and 1980s saw the development of OSH laws and regulations throughout the UK, NI and the Republic of Ireland. In parallel with this a variety of different professions began to express an interest in OSH issues, each bringing particular perspectives and models for the causes and solutions to workplace accidents. There was often conflict between these perspectives and thus between the professional bodies and it has been suggested that the various competing powerful interest groups sought to "cultivate their own specialties" and guarded their position jealously, (Garavan 1997). Legislation acted, albeit unintentionally, to ensure an ongoing interest in OSH and promoted the growth of these professional bodies, usually as consultants to industry and government, (Garavan 1997). By the 2000s there were a number of professional safety bodies with tens of thousands of members at both national and international level. This represents a substantial vested interest in acquiring and maintaining a hold over all aspects of OSH, including the content and accreditation of OSH training programmes.

The development and growth of this large safety constituency has created a discord in how safety elements of professional competences are acquired. In the field of engineering, professional codes have been the guide to design that ensures structural integrity and fire and occupant safety. As construction regulations developed in Europe, USA and Australia, they placed duties on employers regarding the safety and health of workers on site, but there were only limited corresponding duties placed on architects and design engineers as regards site safety, (Gambatese et al. 2009). In the UK the Construction (Design and Management) Regulations (CDM) came into force in 1994 but they were criticised because of their undue complexity and the bureaucratic approach adopted by duty holders that rendered them less than effective in achieving their initial objectives, i.e. the duty of designers to assess the hazards associated with their designs and to design out or provide sufficient information to contractors to ensure the safety of site workers. New CDM regulations came into force in 2007 that required the elimination or reduction of hazards at the design or planning stage, the management of remaining risks on site and the reduction on bureaucratic adherence paperwork.

Though early in the life of the new regulations, Gambatese et al. (2009) have conducted research into the effectiveness of the regulations on the construction industry and the results from focus groups of six professional communities in the industry have highlighted a number of barriers to the successful implementation of the regulations, including a lack of designer education and training, difficulties in assessing risks (because of differences in risk thresholds between assessors), lack of knowledge on the regulations, and a continuing requirement for an extensive amount of paperwork, (Gambatese et al. 2009).

The paperwork issue is not a problem that stems solely from the CDM regulations; it is a widely practiced problem throughout all industries in respect of safety assessments. In 2008 the Works and Pensions Committee of the UK Parliament established a working party to examine health and safety and in particular the problem concerning the over-documentation on risk assessments and the requirements to fill in 40, 50 and 60 page assessments, (WPC 2008). One of the authors (McAleenan P) responded to the consultation stating that the problem arose as a result of a misinterpretation of the regulations in the earliest days after coming into force and which has subsequently become imbedded in the universal consciousness of the profession including becoming a central element and error of training programmes on risk assessment.

The growth of a large safety profession with jealously guarded interests, the shortcomings of education and training highlighted by the professional colleges in the construction industry, the overly bureaucratic application of the regulations and the subsequent finger-pointing amongst the professions about who is to blame (John Penrose MP in WPC 2008) suggest the need to rationalise OSH education and training, placing it within the competencies of those responsible for the health, safety and welfare of workers and consumers and thus on the syllabi of all courses and programmes of professional and vocational study. In 2003 at the 2nd international seminar on OSH education and training this was recognised as a necessity by the International Social Security Association, a body comprising government agencies tasked with social security matters,. Titled the Québec Protocol it calls for educational institutions to work with prevention bodies and employers to design vocational and technical education programmes that have integrated OSH competencies into the education and evaluation processes for all occupations and that the institutions themselves adopt exemplary OSH practices, (ISSA 2003).

In the UK the Joint Board of Moderators (JBM) has determined that graduating engineers must demonstrate attitude, knowledge and a degree of competence particularly with reference to health and safety, (JBM, 2005). Prior to awarding chartered status to any of its members the Institute of Civil Engineers (ICE) requires of its members that they have a sound knowledge of OSH and the consequences on site workers' safety that arises from their professional activities. Currently it is in the process of increasing the profile of health, safety and welfare (HSW) within the industry among professionally qualified engineers through the introduction of the Construction Health, Safety and Welfare Register. Register Members must be professionally qualified, have built on their HSW competence level above that demanded at the Chartered Professional Review, have been peer reviewed, and have met the additional attribute standards. Applicants must demonstrate that they have sound knowledge of scientific, engineering and technical principles, experience of construction processes and knowledge that extends to future use, maintenance and demolition. This route is open to any chartered professional engineer and is not restricted to ICE members, (ICE 2009).

Whilst it may appear that this would be establishing another "safety" profession, what is significant is that the JBM and ICE are driving the re-integration of OSH into the competences of engineers and that professional advice and support is coming from within rather than outside the profession. Nevertheless, despite the numbers of graduate engineers who go on to achieve chartership, the results from the research by Gambatese et al. (2009) on CDM and Schleyer et al. (2007) into risk awareness amongst engineering students indicate that OSH is yet to be integrated into engineering programmes of study.

The authors' research aims to present a critical analysis of the diverse and flexible approaches to developing engineering and more specifically OSH competences that are available at an international level, seeking to learn from global best practices the educational and lifelong learning practices that are transferrable across international boundaries.

As a follow up to their presentation to the CIB W099 conference, "Working together: planning, designing and building healthy and safe construction industry" (2009), hosted by the Royal Melbourne Institute of Technology (RMIT) McAleenan and McAleenan undertook a scoping study of OSH education for engineers for examples of integrated practice and positive outcomes in this regard. Though widely separated and in some cases being still at the research stage, there is a range of promising projects underway that have the potential for wider dissemination beyond the bounds of individual universities and countries. In Melbourne post-graduate architecture students learn materials handling and on-site safety through supervised practice in the formal setting of the university and the informal setting of rural indigenous communities (O'Brien and Hill 2009); in Limerick University engineering ethics are developed through the study of engineering failures, (Phillips 2008); in Aveiro University post graduate civil engineering students have two compulsory OSH units with applied practical work and two optional units for those who wish a more thorough grounding in risk assessment and risk management, (Rodriguez and Cardoso 2009).

The research has also shown that different methods of delivery coupled with variations on the emphasis given to OSH programmes result in widely different outcomes, both negative and positive. When the programme of study was considered of little extrinsic importance to the final qualification, there was little change in student attitudes towards and awareness of risk, (Schleyer et al 2007). On the other hand, programmes that were both compulsory and involving practical self-learning action by the students proved to be successful in developing students' awareness and competences, (Phillips 2008, and Howarth 2009). This demonstrated the need to also examine educational theory and engineering with view to determining which learning models are likely to have greater efficacy. Pedagogies that utilised elements from and a combination of Frieran dialogics and conscientization (Friere 1970, 1972) and Illichian destructured schooling (Illich 1970) were observed in some of the more successful problem based learning (PBL) methodologies that were employed by Phillips (2008), Howarth (2009) and Ramsay and Sorrel (2006).

To date the authors have engaged with many educators from across the world, who have worked steadily on the development of OSH competence within the engineering fraternity, each with their own approach but with the common aim of producing the next generation of competent engineers and this paper gives a flavour of that activity. Clearly there is much transference of knowledge and cross-fertilisation of ideas still to happen but if it is to happen then a lot more pooling of the common knowledge needs to take place and experimentation with tried and tested methods in the various jurisdictions and cultures.

## Literature review

**Educational theory and pedagogies**

The sum of human knowledge is expanding exponentially and impacting on the rate of technological progress such that 100 years of progress may be achieved in a space of 25 years if maintained at the current rate, with the potential for 20,000 years of such progress being achieved by the end of the 1st century of this millennium, (Kurzweil 2001). In the transformation to a knowledge-based society new knowledge renders obsolete older knowledge with its useful lifespan ever shortening absolutely as well as relative to the increasing human lifespan. In past centuries the interval of social change resulting from the outpouring of new knowledge exceeded several lifetimes, but those of us alive today with a life expectation of over 70 years may experience several social change intervals, (Kim 2008).

In educational terms this places substantial demands on the capacities of educational institutions to keep abreast of this outpouring of new knowledge even whilst they are involved in creating it, and the capabilities of the formal structures to deliver a current and relevant syllabus. It is not beyond the realms of possibility that students entering technological courses will find that the knowledge obtained in their first year will be obsolete by the time they take their final examinations. This transforms the fixed period of learning typical of Industrial Society to one of lifelong learning that in the IT Society takes place periodically throughout the life of the learner and in response to workplace and professional developments. Kim (2008) argues further that the continuing growth of knowledge will lead to what he terms the Ubiquitous Society within which learning is uninterrupted and will take place within a ubiquitous cyber environment that is unique and particular to the individual and accessed via all the emerging cyberspace technologies.

Whilst this is current thinking, it is by no means new. Illich (1970) described the limitations of formal schooling both in terms of the inadequacy of the fixed school structure to provide the learner with all the knowledge necessary to play a real and meaningful role in the world around him but also how the structured nature of the educational establishment tended towards selectivity in what knowledge was transferred and thus to the politicisation of schooling. He made the case for open schooling where-in the environment of the community and the workplace were more valid locations for learning to take place than those within the physical and intellectual bounds of a formal institution.

Paulo Friere, the Brazilian pedagogue held that in the absence of an education or in exposure to an education agenda that was limited and serving the interests of a social elite, the learner was enslaved. He developed a pedagogy that aimed to liberate the learner by returning responsibility for his education to himself. The process commenced with learners coming together in a group to explore the environment in which they inhabited through an external dialogic that aimed to make sense of the world via their own experiences and interpretations of it, (Friere 1970). In its development this led to conscientization, the achievement of an in-depth awareness of the world the individual inhabits with a perception and an exposure of political and social contradictions, (Friere 1972).

**Ethics**

Friere's work finds resonance in the studies by Phillips (2008) at Limerick University and Tow and Loosemore (2009) in University of New South Wales, in the sense that engineers have ethical obligations in respect of good business practices, site safety and environmental protection.

Tow and Loosemore cited studies that showed that unethical practices in engineering and construction took place globally and their research found that, amongst other factors, the absence of ethics training at third level education and in the workplace was a major contributor to the problem.

Phillips detailed the problems associated with professional achievement where material wealth was the defining measure of success. In the light of Tow and Loosemore's findings this may be qualified as materialism vs ethics. To overcome this he established a programme that required his students to study a number of cataclysmic engineering failures. It was necessary to the overall success of his students degree programme that the metrics of economics be decoupled from those of education in order for a "value system that promotes leadership and the utilitarian tenets of improving the quality of living standards for society [...] be developed", (Phillips 2008). The methodology adopted involved the students as individuals and as groups exploring the ethical issues arising in the study of the forensics, debating amongst themselves and arriving at a personal maturity as a result. In this process was the commencement of what Dauphin (2002) describes as the individual nature of competence in that each aspiring engineer brought to the learning environment in which they were functioning "unique skills and personality characteristics".

**Problem based learning (PBL)**

PBL was adopted by number researchers with a high degree of success. Phillips (2008) used this method to assist the students develop ethical thought. Howath (2009) under the term "enquiry-based learning" involved his students at the School of the Build Environment, Northumbria University over a two year period in the development of a multimedia teaching device that would have real application for workers on site. He saw that the traditional separation of teaching and research was not appropriate and that the enquiring learner gained more benefit, with a greater depth of learning and understanding through guided and self-directed research. Students utilised elements of Illichian deschooling in that the projects required that they go on-site to observe, consult and interact with workers and develop solutions directly related to their requirements.

Schulze (2006) at the Department of Industrial Engineering, University of Houston utilised a similar approach with his students. "Laboratory experiences [were] intermingled within the course to integrate concepts through demonstration" and that included work in the field. The programme was designed to meet the academic requirements of the students and also to provide a method for evaluating potential interns and/or employees. Student outputs included training programmes for use within industry.

In Melbourne University post graduate architect students, by dint of their maturity, are introduced to site materials and tools and safety issues initially through practical construction work on the campus and subsequently in a real world setting through the design of and personally constructing projects in indigenous communities in Australia and Thailand, (O'Brien and Hill, 2009). The experience brings the students to an appreciation of the impact of the materials chosen on the construction process and the safety of the worker on site, as well as developing the skills necessary to establish and maintain relationships with the workers and communities who will build and occupy their projects.

**Cross-disciplinary co-operation**

Keren et al. (2006) posited that the most important dimension of change in the learner is the acquirement of appropriate patterns of thinking and in this they are concerned with the psychology of thought and behaviour. Though it is not evident from their paper that a psychology element was included in their studies the work of others showed that in engineering it is becoming essential to consider cross-disciplinary input to the students' studies. Phillips (2008) in particular organised short seminars on planning, marketing, insurance, law, communications, dispute resolution and leadership for his students with a longer structured collaboration with the law department in the 2008/2009 semester. In Japan education for the aviation industry includes research based on cognitive sciences and information processing theory, (Hojo, 2005).

## Research methodology

As an early stage research project the adopted methodology is essentially a literature review and critique of the competence development activities happening across the world. Through networks such as CIB the authors have identified a number of key and interesting competence development projects which has added to the current level of knowledge presently held. As the research progress direct contact will be made with the researchers identified with a view to holding face to face talks with the tutors and their students, to ascertain the positives and negatives of their approach and to identify aspects of the programmes that are directly transferrable to other universities and learning organisations.

## Findings and discussion

This study set out to examine a range of structured (as in fixed) and flexible including adaptable approaches to the integration of OSH competencies in engineering education. There is nothing new in the idea that those who design and construct a building should be held accountable for any failings in their design that leads to injury to another. Lawmakers are developing regulations that are not about supporting this as established practice, but are about compelling designers to adopt the practice, (McAleenan and McAleenan 2009). In Australia three jurisdictions (Western Australia, Queensland and South Australia) have statutes that oblige designers to address safety with a fourth, New South Wales, requiring safety through design on public works projects over $1m. (Gambatese et al. 2009); and in the UK the CDM regulations 2007 impose similar duties on designers. But the regulatory compulsion to design in safety does not automatically translate to a requirement to include OSH education and training as a compulsory component of engineering education. Several variations on how it was introduced and covering both compulsory and optional units were examined. In Schyler et al. (2007) undergraduate students were provided with risk education as part of their engineering programme and were surveyed at the beginning and end of the year to ascertain the change in levels of awareness and understanding of risk. The general outcome was that whilst there was a small and statistically significant improvement in the end-of-year scores they bore no relationship to the overall end-of-year examination scores. It was felt that the improvement was probably due to practice effects and general learning effect rather than as a result of formal tuition. This is because the risk awareness tests had no bearing on their examination scores and as such, despite any intrinsic value the programme may have had for students, the absence of an extrinsic value meant that less effort was put into the programme. This is likely to be the trend should OSH units remain optional where they are introduced.

Aveira University in Portugal developed four units of OSH education for engineering postgraduate masters students, two of which were compulsory (one in each year of the programme) and the other two optional, (Rodriguez and Cardoso, 2009). The results of the students self-rating of their attitude towards and knowledge of construction OSH management showed significant and substantial upwards improvement between undergraduate and 1$^{st}$ year master and gain between 1$^{st}$ and 2$^{nd}$ year masters. Noteworthy too was the fact that 46.7% of the students also undertook one or both optional units.

Rodriguez and Cardos found that those who undertook only the compulsory units were consciousness the on-site OSH issues and their obligations and were deemed capable of further self-learning or professional training and demonstrated a desire to undertake such before they were willing to conduct a safety co-ordination system. Those who had undertaken all four units felt that they had gained a major and positive evolution in their knowledge and understanding but despite this still felt it essential to gain experience integrated in specialised construction design and execution teams. This consciousness is a central to the developing competence of the aspiring engineer and if maintained throughout their professional life will lead to spheres of excellence wherein the individual is competent to become competent, (McAleenan and McAleenan 2009).

Both of the above approaches involved distinct OSH education programmes. In Melbourne University, O'Brien and Hill (2009) adopted a different approach where-in OSH competences were developed in association with specific practical projects that required the students to become aware of and develop safe practices in the laboratory and in field. Commencing after their architecture students had entered the post-graduate programme and had demonstrated an appropriate level of maturity they developed a programme that in the first year required the students, under supervision to build their designs in the grounds of the university. The purpose was to gain knowledge of how their designs translated into an actual construction process and how their chosen building materials impacted upon that process and those who had to construct the design. In the process they became aware of and were required to address the safety issues associated will all aspects of the construction. The second stage of the project required that they design and construct a larger project either in an indigenous Australian community or in a third world community, expanding upon the knowledge and skills gained in their first year. In this stage they were required to pass on the OSH knowledge and practices to workers in their chosen communities particularly as these workers had little or no construction experience.

This approach did not treat OSH as an adjunct to the design and construction process but considered it as fully integrated component of the competences required by the designer, the construction worker and the project manager. In this respect this approach came closest to meeting the requirements of the Québec Protocol, though as a project within the architecture department it cannot be assumed that the university as a whole has adopted exemplary OSH practices.

What we are seeing so far is that compulsory units integrated into practice appear to bring about substantially greater benefits for OSH competency than do voluntary codes and optional courses of study. In the Aveira University study it is not yet apparent whether the graduating engineers will progress to practicing engineers fully cognisant of and exercising their OSH duties or become consultants in the vein those described by Garavan (1997) jealously guarding their own specialities and directing other in how to "do" safety.

Innovative methods of promoting learning have been described in a number of the studies reviewed. Howarth (2009) posits the need for "engaging, relevant and challenging [...] learning experiences [that] are essential for the development of people...", and Kim (2008) makes the case for educational institutions to create environments appropriate the ubiquitous society and to actively prepare to meet the rapidly evolving education paradigm. A number of projects have utilised PBL in various formats with Ramsay and Sorrel (2006) concluding that "it results in greater student learning, more class participation while providing the students with the ability to see their instructors as mentors and guides, not simply the 'sage on the stage'".

The majority of studies described in the literature relate to the education of undergraduate and post graduate students in engineering. Over the past ten years the authors have exchanged correspondence with Ron Greenman at Bates Technical College (BTC) in Tacoma, USA. Initially the correspondence centred on the development and implementation of Operation Analysis and Control (OAC) a new paradigm for safety in the workplace. Greenman lectures in fire engineering and in recent years he worked with a student who is a professional engineer with some 25 year experience in the field but absence the formal degree in engineering that was a required requisite before he could be accepted onto a master programme. Greenman assisted his student gather together a portfolio of all the qualifications he had gained from various colleges, short-programme courses, and professional experiences especially in verifiable projects that he had undertaken. He then assessed these against the credit requirements for the bachelors degree and supplemented the gaps with a tailored short programme at BTC. His candidate was awarded the degree and subsequently went on to obtain his masters degree in engineering through a correspondence course.

Though not specifically related to OSH competences, it illustrates the importance of recognising that learning is a continuous process the majority of which will occur in non-formal settings and unrelated to formal educational programmes. It is analogous to Kim's ubiquitous study environment where learning is individual and customised and will take place across time and locations, (Kim 2008).

Contiguous with this is the notion that specialised learning has grown too far away from other disciplines that are capable of providing essential insights and understanding of the chosen profession. In his description of the exponential growth of knowledge he omitted that aspect of increased knowledge that in its practical utilisation transforms the learned man from one knowledgeable in many things to a specialist who excels in one area and has limited or no knowledge in other fields. In the industrial age knowledge became compartmentalised but in this highly technological and information age the absence of broad based learning outside the specialism is being viewed as detrimental to the specialist and conducive to unacceptable practices, whether deliberate or unintentional, (Tow and Loosemore 2009). The work of Phillips (2008) in Limerick illustrate clearly the benefits of bringing together the disciplines philosophy, law and so forth to enhance the ethical aspect of an engineer's educational development. Behavioural safety looking at individual performance requires an appreciation of psychology, and at group performance an appreciation of sociology. Teacher education since the 1970s and earlier has required the student to undertake study in all these disciplines in order to assist his understanding of pupil behaviour, learning strategies and his own reasoning for teaching. For the engineer a similar set of understandings is as essential to his growth.

This paper has touched upon a wide range of educational practices across the globe. There are many different projects being undertaken, some of which are complimentary, and others culture specific. In 2001 one of the authors (McAleenan C) introduced OAC to the ISSA Construction Sector conference in Paris. It was taken by one of the delegates back to Australia where it has been implemented in various degrees on construction sites across Melbourne, (conversations with G. Ayers at CIB W099 Conference, 2009). Good ideas spread rapidly if there are the resources and the commitment to disseminate them. Donaghy (2009) has identified the need for resources to bring together examples of good and successful practices and for international comparisons on the efficacy of these practices on the accident fatality rates. Though many of the examples described here are of recent origin, there is scope to develop research projects that will conduct such comparisons over longer periods of time in order to determine which are efficacious and viable within current and future social change intervals.

## Conclusion and Further Research

The purpose of this paper was to explore the viability of structured and flexible approaches to development of OSH competences in the education of engineers. It was conducted in the first instance as a literature review taking examples from Europe, USA, Australia and the Far East. In the academic field and amongst international influential bodies such as the International Labour Organisation (ILO) and ISSA and some national governments there is an acceptance of the need to develop and enhance OSH competences in the construction industry which is not reflected in universal practice on the ground.

Pedagogical theories and models developed in the 1960s and 1970s are resonating in a number of the cases studied with varying degrees of success in imbedding OSH awareness and competence in graduating engineers. There is no absolute, no one solution that stands head and shoulders above the rest proclaiming that this is the way forward. Donaghy (2009) identified gaps in research which if they were to be conducted could help to produce some practical solutions for the future OSH improvements across the construction industry. One such area Donaghy identified is international comparisons of good practice and the correlation with fatal accident figures.

The authors contend that developing OSH competences through flexible and structured learning is central to the delivery of safer construction products and that there is a vast array of research projects, which if collated into a compendium of global best practices case studies, preferably web-based, which if managed and maintained would provide educators with a key resource. Building on the work of Greenman (Bates Technical College) the authors propose a collaborative research project to determine the viability of developing an internationally recognised flexible learning model for acknowledging, assessing and accrediting prior engineering learning, gained across a range of multi-disciplinary education and training sources, with a view to determining academic equivalents that will allow the conferring of 3rd level qualifications to mature and experienced engineers, whose professional lifelong learning, although flexible, reflects a high standard of academic achievement.

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# SAFE-T-CERT: AN IRISH SOLUTION TO THE UNIVERSAL PROBLEM OF ASSURING CONSTRUCTION SAFETY.

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## ABSTRACT

The construction industry places unique demands upon employers to ensure the occupational health and safety of its employees and of everyone associated with their activities. Consequently over recent years occupational Health and Safety Management System standards have emerged, along with audit schemes related to particular industries. The primary purpose of such schemes is to bring about a culture of continual safety improvement across the construction industry. The work described in this paper explores the development of Safe-T-Cert in the Irish construction industry, charting its rise to prominence, particularly in Northern Ireland. Setting safety audit schemes in the context of global initiatives, the research found that many factors in the current climate, such as integrated management systems and UKAS accreditation, threaten the stronghold position enjoyed by the Safe-T-Cert scheme. The authors conclude that while there is merit in construction-specific certification schemes, caution is needed in their implementation, since the drivers for success are government and clients' support.

Key Words: construction safety, management systems, assurance scheme

## INTRODUCTION

In the early part of this century the construction employers in Ireland were lobbying Government for policy changes that would yield safety improvements across the industry. In Northern Ireland, the Government response was to launch Buildsafe NI (2003-08), a 5 year initiative, which set out to engage all parts of the industry in a series of actions that would yield a 50% reduction in reportable major injuries. Cable and Haupt (1999) proposed that Governments can play a role in promoting that safety and health management systems be integrated into the entire construction process. One specific action taken by the NI Public Sector was to require all of its principal contractors to have an independent 3rd Party audit of the their safety management systems before being able to tender for work. Safe-T-Cert emerged at that time, as an occupational health and safety (OHS) management system audit scheme owned and operated by the Construction Employers Federation (CEF) in NI and its sister body in the Republic of Ireland the Construction Industry Federation (CIF). This was not entirely coincidental, since the CEF had been lobbying Government to take some positive action to improve the industry's safety record. And while the Government cannot be seen to endorse commercial products, their direct involvement in the development and ongoing monitoring of the Safe-T-Cert scheme, and specific reference to it in their literature (2004) gives tacit approval to the product.

This gave contractors using Safe-T-Cert confidence that it is a sufficiently robust approach to certification. The Institution of Occupational Safety and Health (IOSH) and Roads Service NI (a public sector client body) assisted in the development of the Scheme. IOSH continues to oversee the competence and integrity of its auditors. Additionally HSENI and HSA (RoI), trade unions, clients, contractors and professional bodies are represented on Safe-T-Cert's Joint Standards Advisory Panel (JSAP).

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## DEVELOPMENT OF THE SCHEME

Initially conceived as an idea culled from the Petrochemical industry in Holland and elsewhere, Safe-T-Cert addresses the diverse needs of construction contractor companies in both parts of Ireland. This certification scheme takes account of the best practice guidelines for Occupational Health & Safety (OHS) management systems of relevant national and international bodies, including the International Labour Organisation (ILO-OSH 2001) and BS OHSAS 18001. Certification of a contractor to the scheme requires proof of compliance with all current regulations and evidence of measures being taken towards continual improvement. The scheme, which is also recognised under the Construction Safety Partnership in RoI, assures clients that certified contractors operate effective OHS practices. It provides 3rd party evidence for contractors in pre-qualification and selection. Development of the scheme's protocols was also assisted by the EU Adapt Initiative – which aimed to support the acceleration of adaptation to industrial change (Burke 2005). This cross-border initiative has facilitated the sharing of experience and expertise in refining procedures, and the sharing of resources such as the panel of auditors who can alternate between jurisdictions. The scheme has undergone gradual improvement since its inception. Early teething problems, which are common in the introduction of innovative systems, required a detailed management review. In 2007 an independent consultant was appointed to provide a review of the scheme and to provide detailed advice on the training of the scheme's auditors. The report has not been made public.

Safe-T-Cert is accepted by the International Register of Certified Auditors (IRCA) as an acceptable alternative to BS 18001(2007); in 2007 Safe-T-Cert was recognised as providing full qualification for registration with the UK's Construction Health & Safety Scheme (CHAS) without the need for further assessment. CHAS has more than 400 purchasing organisations such as councils, housing organisations, NHS Trusts and private companies who employ sub-contractors. Its aim is to prevent duplication in assessment of competence in safety management, so that recognition by it affords contractors and others equal status for pre-qualification for construction contracts in Great Britain. The SAFEContractor Certification Scheme, based in Wales, provides a similar status to Safe-T-Cert across Great Britain and is also recognised by CHAS. It is worth noting that at present the owners of these two schemes are not members of the Safety Schemes in Procurement (SSIP) Forum (2010). The Olympic Delivery Authority (ODA) for London 2012 also recognises Safe-T-Cert (2010), stating; "The ODA gives equal recognition to organisations with systems accredited to HSG65...OHSAS 18001, BS 8800, ILO-OSH 2001, ANSI Z10, AS/NZS 4801 and Safe-T-Cert". Constructionline, set up by UK Government and managed on their behalf by management consultants Capita, is a UK register of pre-qualified local and national construction and construction-related suppliers, used by public sector clients as a data base of qualified organisations. Possession of Safe-T-Cert certification exempts contractors from having to complete the Constructionline OHS questionnaire. Almost every significant British contractor is registered with Constructionline. While it is often argued that insurance companies look favourably on contractors who have taken a pro-active approach to safety management through obtaining certification such as Safe-T-Cert, there is no empirical evidence of this.

## AN INTERNATIONAL PERSPECTIVE

Steven (2010) referred to a new standard for international risk management, ISO 31000: 2009, which primarily details the principles, framework and process to improve the identification of opportunities and threats, and increase the likelihood of achieving the health and safety objectives for the project. ISO has stated that ISO 31000: 2009 is intended to be used to harmonise risk management processes, not to replace the standards, and is not intended for the purpose of certification. Internationally, there are many standards for which certification is an option and which IRCA consider to be acceptable alternatives to OHSAS 18001 for the purposes of compliance with their OHSMS auditor certification criteria. These include national schemes in USA, Australia, Singapore, South Africa, Hong Kong, Japan and Indonesia, most of which, like Safe-T-Cert, use OHSAS 18001 or ILO OSH 2001 as the basis of their standards development. This recognition is not intended as a technical review of the equivalence of a standard to OHSAS 18001, but it does confirm the validity of the auditing processes within each of the schemes. Redinger and Levine (1998) strongly advocated the use of 3rd party certification approaches and proposed an assessment model, similar to what evolved as OHSAS 18001: 1999. Davis (2000) expanded their work and examined the relationship between quality and safety as integrated subsets of TQM.

Specifically the Japan Construction Occupational Safety and Health Association (JCOSHA) have produced Construction Occupational Health and Safety Management System (COHSMS) guidelines, a 'self-concluding' system directly linked to ILO-OSH 2001. While there is no 3rd party certification, there is what is referred to as 'External System Evaluation', providing support for contractors seeking an objective view of their reliability. The goal of the USA's ANSI Z10 standard, according to Abrams (2006), is to use recognized management system principles, compatible with quality and environmental management system standards such as the ISO 9000 and ISO 14000 series (as well as with principles adopted by the ILO), to encourage integration of safety into other business management systems. At the present time, there is no apparent Z10 certification scheme.

## REGISTRATION, CERTIFICATION AND POTENTIAL INTEGRATION

Companies certified to Safe-T-Cert have undergone detailed scrutiny and demonstrated that they meet minimum requirements. Upon registration as an applicant for certification, they are provided with detailed guidance on the certification criteria. The application will clearly state the scope of the audit and specify which aspect of the company's safety management system is to be considered. The description of activities must be based on the Common Procurement Vocabulary (CPV) of the European Commission. Contractors are normally required to submit themselves for audit within 9 months of registration with the scheme, during which time they measure their safety management system against the scheme criteria and make improvements as appropriate. When the Contractor is ready the scheme manager will appoint an auditor from its approved panel of auditors. The initial audit will combine a detailed examination of the company's OHS management documentation and procedures with interviews, site inspections and other verifications. A positive auditor report (greater than 51% compliance) will result in the contractor achieving Safe-T-Cert recognition. Continued Safe-T-Cert certification is subject to annual verification audits and random inspections of company sites, selected by the auditors. At the annual verification, the company must demonstrate that their H&S practices have improved, and that all benchmark targets set at the previous audit have been implemented or achieved. After three years of Safe-T-Cert certification, each company must undergo a complete audit. This is akin to the normal practice in management system auditing, where every third year a full re-certification visit takes place, with two surveillance visits having been made in the intervening years.

Underlying the scheme is the principle of continuing improvement, whereby a company uses a combination of internal audit and review, implementation of corrective and preventive actions, setting measurable objectives annually and monitoring of improvement towards these objectives. Again, this is normal management system practice, as in the Plan / Do / Check/ Act cycle adopted in BS EN ISO 9001 (2008) and BS EN ISO 14001 (2004), as well as in BS OHSAS 18001 (2008). There is a case to argue that companies aspiring to hold certificates for all three of these compatible standards could easily combine them allowing a firm to develop an integrated management system (IMS). McAleenan (2010) posits that an effective management programme will integrate quality, safety, environment, resources, etc. into a unified structure where the key decision makers act in unison to meet the project objectives. Lingard and Rowlinson (2005) proffered the idea that for many construction organisations, "launching an OHS management system on the back of a pre-existing quality management system is likely to be the easiest route to the implementation of a systematic approach to managing OHS". Manzella (1997) promoted the applications of Total Quality Management (client satisfaction, system focus, zero defects and measurement of performance) to the management of OHSAS. Alves Dias (1999) argued that all systems applicable to construction sites (environment, quality and safety) should follow similar methodology and suggested that their systems could be integrated. He took the existing 20 sections of ISO 9001 (Quality Systems) and adapted each to OHS applications – before the initial publication of OHSAS 18001.

**COMPARISON OF SAFE-T-CERT WITH BS OHSAS 18001 (2008)**

Safe-T-Cert is clearly a simpler and more construction-related approach to certification than BS OHSAS 18001, since the scheme requirements allow certification when the company has demonstrated it is partially in compliance with the standard. An initial assessment score of 51% of the possible score is enough for entry to the scheme, although in subsequent audits firms are required to demonstrate continuing improvement in the company system - as evidenced by an increased grade. This is justified by the proponents of the scheme on the grounds that it is better to have organisations signed up to a programme of improvement through membership, rather than excluding them until a very high level of performance has been achieved. Operators of stricter quality, environmental and safety management schemes would strongly disagree, claiming that a scheme is only as good as its lowest performing member. They would argue that it is easier to enforce prior improvement in order to gain entry to a scheme, rather than to try to persuade existing members to make the necessary effort once they have gained entry.

Some Irish construction organisations already had certification to the three management standards above, so did not change their IMS. However, many companies did see merit in going for Safe-T-Cert certification alongside or instead of BS OHSAS 18001, because of its practical construction-adapted approach. What was initially viewed by some as "OHSAS for Dummies" was rapidly seen to be a company-friendly, practical approach to the management of construction safety. However, there is no detailed, published standard for the scheme, so its effectiveness depends very largely upon the competence of the auditors. Auditors have to be as well qualified as auditors to the three international standards for OHSAS, QMS and EMS, and the auditing process is seen by IRCA as no less rigorous.

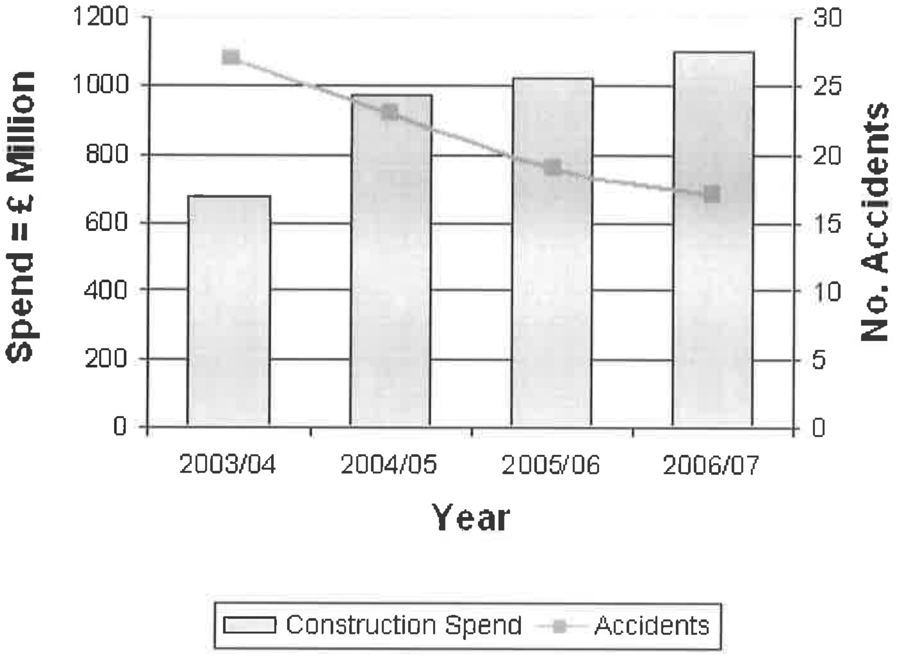
There is a perception that Safe-T-Cert is more appropriate than BS OHSAS 18001:2008 for smaller firms. Given that more than 90% of construction companies can be classed as SMEs, it is not surprising that the former has a much greater take-up than the latter. Companies as small as one-man operations have been awarded certification to Safe-T-Cert; so have very large contractors with a wide spread of activities, including the manufacture of construction-related materials such as pre-cast concrete units and timber frames. Smaller firms do not need to have detailed manuals or documented procedures, so long as they can demonstrate compliance with all relevant legislation and statutory requirements, including the production of a safety policy.

In most instances, only construction organisations which also operate compatible systems to ISO 9001 and ISO 14001 see benefit in the more comprehensive OHSAS 18001 approach (within an IMS), compared to the construction-specific Irish scheme.

**PERFORMANCE FIGURES**

It is now over 10 years since Safe-T-Cert was conceived. Growth was initially very slow until the publication of the Government Construction Clients Group's Action plan for Buildsafe NI (2004). The requirement for certification for public sector contracts led to a rapid growth of interest in the scheme in the NI jurisdiction. In RoI, many firms already held certification to OHSAS 18001 or operated safety management systems to BS8800, and decided that there was no immediate need to change from these. Despite the reference to certification (and in particular to Safe-T-Cert as an example) in the HSA's guidance, the scheme has not gained the prominence in the Republic that was originally envisaged.

Figure 1: No. of accidents on public sector projects compared to spend




(Source Buildsafe-NI (07) GCCGP01- report to Construction Industry Forum (NI)'s Buildsafe NI Steering Group (24/04/07)

There has been a welcome decline in the rate of reportable, serious and fatal accidents throughout Ireland (in terms of number per 100,000 workers). Whilst it is impossible to relate this drop directly to the growth of Safe-T-Cert membership, it doubtless played a part, alongside better training and management practices. Increased awareness of H&S issues can be identified by the fact that the most frequently visited section of CEF's website is that for Health and Safety. Most importantly, of course, is the reduction in accidents and near-misses on site which result from improved management practices, procedures, training and documentation. Towards the end of the 5 year Buildsafe NI initiative the Government reported that the record of H&S performance on public sector projects had improved since the introduction of the initiative. This improvement (Figure 1) shows that despite significant increases in the levels of public sector expenditure, the number of accidents reduced.

**COMPANY EXPERIENCES**

It is enlightening to learn how experience with Safe-T-Cert has been viewed by member companies. Benefits seen include reduced complexity, improved consistency and the development of an effective safety culture. Firms based in the Republic of Ireland, cited on http://www.safe-t-cert.ie/Testimonials.htm (accessed 26/6/2010), commented;

> "In 2007, we requested the Safe-T-Cert auditor to visit our group companies (including a manufacturer of pre-fabricated modules) in both UK and Ireland, thus gaining accreditation for the group's activities throughout Ireland and the UK"

> "The certification is a great way of assuring our clients and employees that we are fully intent on operating a safe working environment, with continuous assessment and improvement."
>
> "Acquiring the Safe-T-Cert was a very thorough process, which has left us with an excellent safety management system to ensure the well-being of our employees."
>
> "We like the balanced approach to document management and physical safety on site, allowing site management to effectively implement the written procedures without undue concentration on paperwork, important though this may be"

It is clear that the tri-partite nature of the Safe-T-Cert approach, involving the endorsement of Government as well as employer and employee organisations, has laid the foundation for an effective safety scheme which operates in the best interests of all involved. In particular, the companies feel that it is their scheme, which works in their interests without excessive red-tape and bureaucracy.

**AUDITOR EXPERIENCES**

In NI auditors and the Scheme Manager meet quarterly to develop consistent approaches to the operation of audits. Auditors do not yet use common check-lists, but it is expected that these will be developed soon. The meetings discuss acceptability of standards and practices, changes in legislation, reporting processes and inspection experiences. Hence auditors are becoming more knowledgeable and consistent each year.

As might be expected, auditors vary in both their experience and approach; hence JSAP has a role to play in trying to ensure consistency. However auditors are rotated annually, to 'ensure fairness'. Whilst this has its merits, there are disadvantages since auditors do not return the following year to verify the implementation of previously agreed improvements. Interviews with auditors revealed that, despite regular meetings which attempt to develop consistent procedures, there is a perception of "sheep and goats" in some auditors' views of their colleagues' abilities and practices. Perhaps this in inevitable with a person-to-person process such as auditing (or World Cup refereeing!).

**CROSS-BORDER COMPARISON.**

There is a marked difference between the take-up of the scheme north and south of the border. In NI the Buildsafe NI initiative gave great impetus to the fledgling scheme by making 3$^{rd}$ party certification a mandatory pre-qualification requirement for all government related projects. This led to the present level of membership of 620 certified companies, with a further 120 applicants presently preparing for membership. These numbers compare very favourably compared with the growth of certification in the Republic of Ireland. Presently there are 105 certified companies listed on the CIF website, with a further 140 applicants in the process of gaining certification. Considering RoI is around 3 times the size of NI, a pro-rata growth in RoI would have seen around 2,000 members and applicants. This imbalance is even more marked when one considers that the construction sector in RoI, at the height of the construction boom [2006] was almost 24% of GDP, twice the average for Western Europe (O'Toole, 2009). At that time it directly accounted for 19% of the entire workforce.

A primary reason for the low take-up may be the lack of explicit Government support for the scheme. While there is no pre-qualification requirement for certification on Government contracts in RoI, the scheme is included under the Competence of Contractor criteria in the HSA guidelines to the Construction Regulations 2006 (the Irish equivalent of the UK CDM Regulations). There is a Construction Safety Partnership in the Republic, but its 2008-2010 Plan sets 6 goals for improvement, none of which refer to promotion of the Safe-T-Cert scheme, or its equivalent.

Another reason for the relative shortfall in membership south of the border may lie in that region's traditional dislike of regulation of industrial activity. This is the philosophy that gave rise to the unfettered growth of the Celtic Tiger, and to its equally spectacular demise. Builders were encouraged to go for growth in supply (O'Toole, 2009), with unprecedented rise in property prices and contractor/developer profitability. This growth in construction was not accompanied by a rise in demand for safety certification, although mercifully there was no significant increase in construction accident statistics. The improved statistics here may owe more to the growth of the Construction Skills Certification Scheme and the award of Safe Pass qualifications to individual operatives and managers.

In summary, there does not appear to be the same enthusiasm for Safe-T-Cert in the Southern construction industry as there is in Northern Ireland. The work of JSAP has not yet been able to drive the scheme in the Republic at anything approaching the rate in NI. It would appear that the only thing that will accelerate growth in certification is enforcement by the Irish Government for it as a pre-qualification requirement on public sector contracts, as exists in NI.

## LIMITATIONS OF THE SCHEME.

The scheme depends almost entirely upon the calibre of its auditors and, in the absence of a clearly documented standard or standardised audit check lists, there are limited official means of ensuring consistency. Auditors have to carry their own professional indemnity insurance, so there may be little likelihood of them risking claims from applicants or members who feel that they have been unfairly treated. The pool of auditors is small (only one in the RoI), so there is a fair likelihood of conflict of interest (or at least the appearance of bias) when they may have been involved in some capacity with the companies that they are auditing, possibly as consultants or trainers. The scheme managers try to prevent this through their allocation of auditors to companies on a rotating basis.

Another weakness is that, unlike the certifying organisations that are accredited by the United Kingdom Accreditation Service (UKAS), the scheme is run by employers' federations, who cannot be considered as completely independent bodies (a normal requirement within the NI public sector's procurement strategy). Whilst membership of the local federation is not a requirement for certification, it may be considered unlikely that the scheme managers will act in a way which upsets their own members.

There have been very few instances where the scheme's appeals procedures have been invoked. Indeed, the fairly low level of compliance required for initial entry, and the relatively benign stance taken with companies who are not improving at the desired pace, has meant that there are very few occasions where companies feel a need to appeal. One of the few appealed cases known to the authors involved a firm who were graded at a level lower than that specified by a particular client as a pre-qualification requirement for a major contract.

## CONCLUSIONS

The development of the Safe-T-Cert scheme holds many lessons for the construction industry. Its example of a locally-operated, construction specific, safety management certification scheme should provide food for thought for the construction industry worldwide. Despite the limitations outlined above (which may well be rectified in the future), the principles of the scheme could usefully be adapted to suit the local market in most parts of the world. The principal requirement is the availability of experienced safety auditors, with a comprehensive knowledge of the local safety legislation to monitor compliance with the scheme.

There is no specific requirement for a scheme to be operated through a trade association such as an employers' federation, although the motivation to establish such a system is most likely to initiate from one. There is a parallel in the establishment of the Quality Scheme for Ready Mixed Concrete (QSRMC) as a separate certification body in 1984, to provide much clearer evidence of total independence than its predecessor, the Authorization Scheme of the British Ready Mixed Concrete Association, which had been operated by this trade association since 1968 (Gunning, 1987). Perhaps in the fullness of time, Safe-T-Cert will seek full accreditation from UKAS as a certifying body, in the way that QSRMC did in 1987. Failure to achieve independent status could, in time, lead to the decline of the Safe-T-Cert scheme.

The attraction of a scheme like Safe-T-Cert for a small organisation is clear. There is no requirement for a quality manual as such, but merely for the establishment of an OHS policy and appropriate hazard identification/risk assessment procedures. A firm with only a single "owner/employee" has been certified to the scheme. Equally, a number of large contractors and other organisations have seen merit in Safe-T-Cert, rather than pursuing certification to OHSAS 18001. Both set out to enable an organisation to control its OHS hazards and improve its performance, but the latter is viewed by many as being unduly bureaucratic and less flexible than Safe-T Cert. Both Safe-T-Cert and OHSAS 18001 may be accused of failing to address product safety, property damage or environmental impact, but there are other certification schemes (as well as local legislation) which may cover these issues. Of course there is nothing in either to preclude the inclusion of any of these in a safety management system.

Many safety management audit schemes exist now within and outwith the construction industry, which potentially threaten to erode Safe-T-Cert's stronghold in the NI market. With the proliferation of such schemes and the lack of mutual recognition, in 2007 the HSE (UK) engaged with various bodies offering independent safety management systems auditing services with a view to establishing a common approach and the avoidance of duplication of effort. The result was the establishment of the Safety Scheme in Procurement Forum (SSIP), which does offer mutual recognition to its member schemes. Crick (2009) commented "*do not think of a CHAS or NHBC or EXOR or SMAS assessed supplier, think of an SSIP assessed supplier. In this way clients have a larger pool of suppliers to choose from and contractors only have to undergo one assessment process*".

At the time of writing the Safe-T-Cert scheme is not a member of SSIP, neither are its owners, CEF/ CIF, UKAS accredited. Effectively this means that for Safe-T-Cert there are no existing benchmarking comparisons of national or international schemes. This situation, if not rectified, could impact negatively on the long-term commercial viability of the scheme.

In conclusion, it is hoped that this review of the Safe-T-Cert scheme may provoke the readership to consider if there is merit in the establishment of a local, construction-specific certification scheme to identify, confirm and improve the quality of OHS management in their region. As can be seen from this paper, it is possible for a single scheme to operate across legislative jurisdictions. The support of local client organisations, particularly in the public sector, may be considered an essential driver, and an independent overseeing body should be established to monitor and regulate the performance of the scheme.

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# Calculating your flight distance – the evolution of safety in the competent company

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## Abstract:

The risk-averse company faces extinction in the marketplace and for the company that ignores risk, their extinction comes at the hands of the courts. The successful company survives because it has evolved a balanced dynamic between productivity and hazard control in which the twin objectives of worker safety (survival of the individual) and profitability (survival of the company) co-exists. This paper, drawing on examples from natural behaviour will describe the evolution of the mental processes behind awareness and assessment of hazards and detail how behaviour is continually modified to ensure the successful achievement of personal and social objectives irrespective of the hazards faced. The paper will show that the processes which ensure safety in nature are those necessary for safety at work and of r the success of the company.

### Key Words

Behaviours, Competence, OAC, Cultural Maturity, Safety.

## Introduction

The behaviour of animals can often be quite surprising to the casual observer, leaving us with a sense of wonderment at their ingenuity, particularly when they behave in ways that are totally unexpected.

Magpies, like many other birds, regularly visit garden feeders and have a particular fondness for bread crumbs scattered on the ground. Their normal practice is to fly down scoop up and eat a piece moving onto the next morsel and so on. Once finished they would periodically return to see if more had been left out. Generally several birds would be observed at any given time, all following similar behaviour.

On a recent occasion a different behaviour was observed. A single magpie hopped from point to point on the surrounding rooves spending a few seconds eyeing the ground below before moving on to another vantage point. Several other birds were perched higher up and some distance off. After a number of minutes the bird flew down to the ground and rapidly scooped up several larger pieces of bread before flying off. It was only at this point it was noted that the family cat was sleeping on the ground close to where the breadcrumbs had been scattered.

What had just been observed was a bird conducting a risk assessment and then modifying its behaviour in order to safely collect as much bread as it could carry in its beak, whilst the other birds stayed away from the situation completely. (It is not known whether the bird subsequently shared its gains with the rest of the flock, but if so that surely would have been a clear indication of group behaviour-modification to achieve a successful outcome).

The above anecdote would not be surprising to animal behavioural psychologists, and for most of us would pass as an amusing one at social gatherings. But from the safety professional's perspective the observation and the conclusion drawn from it illustrates a fundamental aspect of behaviour, animal or human, that is necessary for survival and, when applied to group behaviour for the success of the group. That is the ability to recognise and assess hazards and react to them in a manner that prevents or protects from harm without compromising on the primary objective of obtaining the means for survival.

## Evolution of optimal flight-distance

Where it not for this ability the chances of surviving long enough to propagate the next generation are slim and in the long run would lead to the demise of the species. Failure to recognise sources of harm, e.g. another predator, and to react to them appropriately means that the animal remains in harm's way until it is too late and they themselves become a meal. Recognising what may cause harm (predators) and knowing what to do means that the animal can shift out if it's way in time, and thus live on for another day. Those animals that do this pass on to the next generation the genes that gave them this ability and thus the species evolves into a "hazard-recognising and running-away-in-time" species.

Richard Dawkins (2009) coined the term flight-distance to represent the distance an approaching predator is allowed to approach before the animal flees. Too short and the animal becomes food, too long it risks starvation. There is, he argues an "optimal flight-distance" that will allow the animal as much time as possible to acquire its meal but still give it sufficient space to flee the scene without being caught.

Hazard recognition is a simple binary process; hazard/not a hazard, (1/0) and, for the most part, can be learned from others without the development of complex thought processes, e.g. through imitation. However one possible outcome of this is that the mere appearance on the horizon of a predator could result in immediate flight from the scene. Such flighty or risk-averse behaviour is no more conducive to success than is the failure to recognise the hazard and the end result is likely to be starvation through continual failure to obtain or finish a good meal, and thus a failure to pass on the genes.

Thus the outcome for any species is:-

- Failure to recognise hazard = demise
- Ability to recognise hazard but failure to respond appropriately = demise
- Ability to recognise hazard and ability to respond appropriately = success

More so than the ability to recognise the hazard the ability to respond appropriately to a hazard is the result of complex mental processes that entails assessing a number of factors about the hazardous situation (e.g. location and terrain, it's likely speed, ability to resist it, etc.) and factoring these into the subjective ability and speed at which to flee. Reality prohibits knowing with absolute certainty everything that there is to know about a given situation, thus the assessment of the hazardous situation requires the inclusion of a certain margin of error or risk distance with the appropriate action to be taken on a fail/safe basis, in other words err in favour of survival. Thus the optimal flight distance is longer than the absolute minimum distance but not so long as to be risk-averse, (see Fig.1).

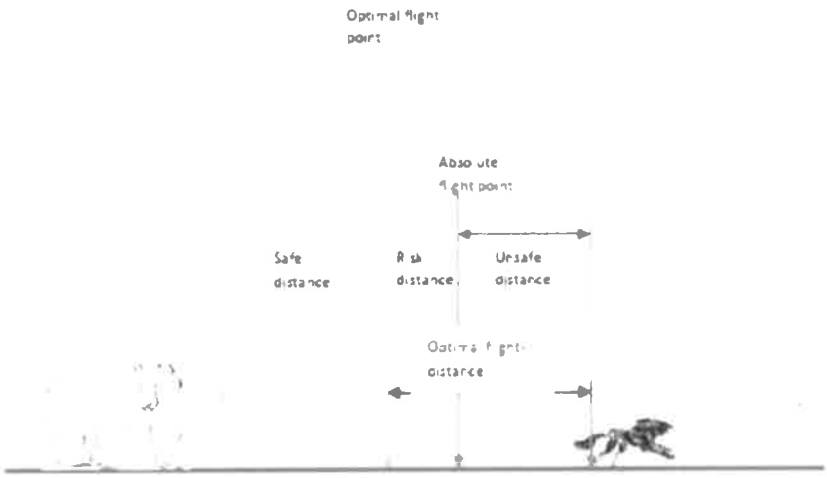


**Figure 1: Optimal flight-distance**

When the bear is at a far enough distance from the wolf, the wolf may continue to feed safely, albeit with a wary eye on the wolf. As the bear approaches it crosses a point which is risky for the wolf to remain as it may have hidden reserves of speed that the wolf does not know about and its decision to remain depends on how hungry or how brave it is. This is the optimal flight point. Finally the approaching bear will cross a point at which it will catch the wolf, a point which makes it unsafe for the wolf to remain, therefore flee he must. This is the absolute flight point. The optimal flight-distance is the sum of the safe and risk distances. The fact that we still have wolves attests to their having successfully evolved the ability to work out an optimal flight-distance.

## Optimal flight-distance and work

Now, when we consider this analogy in the context of work, the optimal flight-distance can be viewed as the point at which it is not safe to commence or proceed with the work activity. Taking all things into consideration, the competent worker will not only be capable of recognising hazards where they exist or when they arise, but will also be able to assess the hazard or hazardous condition and correctly determine what actions he must take to safeguard himself and others from harm. If he is incautious the consequences are clear, the hazard will be realised and he or someone else will be harmed. On the other hand if he adopts too cautious an approach it will result in "risk avoidance" and the work activity not being carried out or, alternatively overdoing the safety measures and thus unnecessarily increasing the time, cost and effort required to achieve the work output. And, just like the flighty wolf that fails (starvation), this too will in time result in the worker failing i.e. losing his job (he is unproductive) or if it is the company culture, the company will fail losing out to competitors that are less risk-averse.

Take for example a simple everyday activity such as crossing the road. In Figure 2a we can define the safe crossing points/times exactly, but only on the basis that we have all the information available to us. Mathematically this diagram is correct but in the real world such precision with regard to crossing road is not achievable in practice and thus the diagram is impractical. In reality the driver approaching may not be paying attention, his vehicle engine may be at the point of failure, or your legs may be feeling the after effects of last night workout in the gym. All in all we would prefer, and usually do build in a margin of additional safety to allow for the variables. When teaching children that margin is substantially greater than we would allow for ourselves.

 

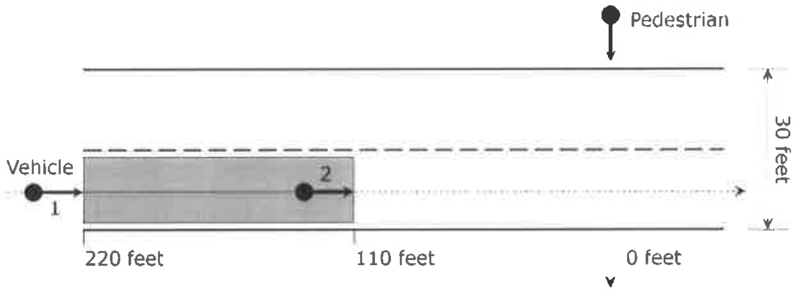


**Figure 2a: crossing the road**

- A vehicle at 30 mph will cover 44 feet per second.
- A pedestrian at 4 mph will cover 5.9 feet per second
- To cross a 30-foot wide road will require 5 seconds.
- A car between 110 feet and 220 feet from the crossing line will **certainly** hit the pedestrian.
- All things being equal he will have to cross before the car reaches the 220 foot point or wait until it has passed the 110 foot point to be **certain** of crossing safety.
- If he doesn't have this information he cannot be certain and the car is close to these points, then there is a risk.
- The risk is from lack of knowledge; the two options hit/not hit remain the only two options whatever percentage risk is attached.

A more appropriate diagram for actual behaviour in crossing the road would look like Figure 2b. If the pedestrian determines all zones to be hazardous and postpones his crossing until after the vehicle has passed the nearer amber zone or indeed crosses before it reaches the furthest away amber zone, he will not meet with an accident, (note: the length of the further zone may be longer depending on the confidence the pedestrian has in himself).

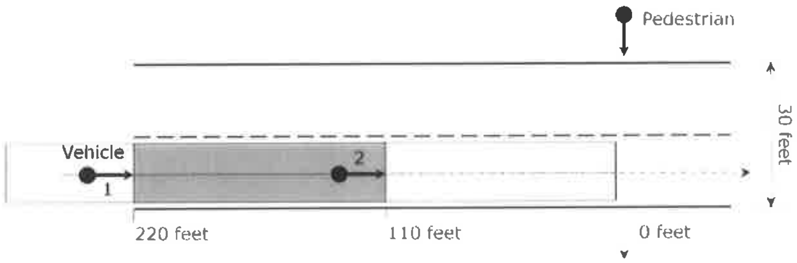


**Figure 2b: crossing the road with additional margin of safety**

Success in work as much as in any other activity therefore requires a rational balance of precautions necessary to safely carry out the task(s) and achieve production objectives with sufficient additional precautions to allow for a margin of error, i.e. to allow for unknown factors. Generalising this we can now modify Figure 1 and schematically illustrate the work situation as per Figure 3.


**Figure 3: decision zones**

In this case there are three zones.

| | |
|---|---|
| **Hazard zone** | Where hazards exist and are not controlled/fully controlled |
| **Risk zone** | Where potential new hazards may arise and which therefore requires additional controls to safeguard against them (e.g. the use of redundancy systems). |
| **Safe zone** | Where the hazards are known and are controlled by a combination of engineering, process, behavioural and PPE controls |

 

The flight point or condition at which the work does not commence or ceases if started is that point when one or more of the known hazards are present and uncontrolled. Prior to commencement of the work activity the ideal conditions required are those described in the safe zone with optimal conditions being a combination of precautions/controls described by both safe and risk zones.

After the commencement of work the decision to cease will be based on the failure of any of the controls already in place or the occurrence of any hazard or hazardous condition that shifts the safety of the activity into the hazard zone.

## Evolution of multiple strategies

For the purposes of clarity the wolf/bear analogy has been simplified to illustrate a single solution to necessity, i.e. flight from danger. In practice there are options, some of which are successful and therefore passed onto future generations, e.g. if the wolf had stood its ground, challenged and bested the bear, strength and ferocity would pass on and the result is variation in the species. This use of alternative strategies has been observed in chimp behaviour. The popular view has been that the alpha male, being the strongest, had mating advantages over other males whose success in getting access to females was related to their ability to successfully challenge the alpha male, usually in a fight or show of ferocity. However it has been observed that some chimps used guile and had a rapid dalliance with females when the alpha male was distracted (often when fighting off challenges from other chimps). This didn't produce two separate types of chimps, the strong and the smart, but rather overtime produced a troop with strength and intelligence mixed throughout.

With ever increasing degrees of complexity these examples illustrate that the success of the individual and the group is dependent upon the development of successful strategies for achieving individual and group objectives and in that most complex of social groups those objectives are much more than for mere survival and reproduction, (though when we strip away all the superfluous these two objectives are at the core of all human activity; as biological imperatives they are unavoidable).

In human terms the evolution of the ability for complex mental processes has in turn led to the evolution of a cultural replicator in much the same way as the gene is a biological replicator. The meme, another term coined by Dawkins (1976) is a unit of cultural ideas, symbols or practices which replicates and spreads throughout social groups. The more successful memes endure over time and across large portions of society with relatively little change. An example would be a simple string of musical notes such as the da-da-da-d'dah of Beethoven's Symphony #5, or the idea, "PPE is good".

Returning to the idea of a single strategy, successful though it may be, it is fundamentally flawed in that when circumstances change or new conditions manifest themselves that strategy will fail. Indeed all strategies have the propensity to fail simply because they have evolved or been developed to meet particular circumstances. A bank of successful strategies, whilst tending towards greater success, nonetheless contains that same flaw; being finite they cannot effectively respond to every possible circumstance that will materialise. What was required was the evolution on an ability to develop novel strategies and the apex of this evolution (to date) is the intellect.

As we have seen with the magpie, a key function of this ability is to appraise each new circumstance, assess the situation, develop and apply an appropriate strategy that will achieve the core and subsidiary objectives. It is a complex thinking process that in its execution also requires an ongoing, dynamic assessment of the developing situation and the making of judgement calls; the magpie is no more able than the ordinary pedestrian to perform the necessary measurements and calculations in the concrete situation to make a totally objective decision. Kundley, et al (2010) shows that dogs can represent for themselves how others perceive their actions. When silence is germane to obtaining food dogs would select the food container with the muted bells (ignoring the one with ringing bells) whenever they thought that the observer, though still present, was no longer watching them. Beckoff, University of Colorado, (cited in New Scientist 2010) commenting on their results states that human mental abilities are not unique.

Additionally and crucially the process is capable of developing a number of solutions for each situation; magpies in a flock are known to chase single predators and in the above anecdote they could have done the same vis-a-vis the cat potentially making it safer for all to eat on the ground.

In the work situation, companies and employees who recognise and practice this have a greater adaptability that those who opt for the one situation/one solution approach. Take for example risk at a macro level, namely the risk of closure in the face of economic downturn, a very real prospect for companies throughout the world at present.

For many companies, the one situation/one solution to a severe downturn in sales is to downsize or closedown completely. Bottom-line thinking looks to the continuing profitability of the business and where that is severely compromised – the flight option is chosen. In the 1970s the Board of Lucas Aerospace in the UK proposed the closure of the Bristol plant which was uneconomical. This step would prevent the continuing drain on company resources and therefore on the profits. It was immaterial that the workers would be made redundant, unemployed and dependent upon welfare. However the shop-stewards combine proposed a range of alternatives that would utilise the existing skills of the workforce and technology in the factory to produce socially useful technologies (e.g. white goods for domestic consumption). But these options were rejected and the company proceeded with the closure of the plant (Doyle 1998).

Faced with similar prospects in the 1990s in Brazil, Ricardo Semler (2001) radically transformed the nature of his company, not only in what they produced but in how the company was structured including the decision making process. Many of the solutions arrived at by Semler and his workforce were not dissimilar to those proposed by the workers of Lucas aerospace and a heavy industry company, manufacturing pumps for the shipping industry turned it resources to producing light technologies for domestic and retail consumption. The company survived as one of Brazil's and indeed one of the industrial success stories of the 1990s.

And currently in Argentina workers' groups are successfully developing alternative solutions to closures in many factories and service industries and as a result of their actions instead of closing the industries are thriving. The Lavaca Collective (2007) estimates that over 170 companies and 10,000 workers have benefited from these activities.

In these examples we see that the risk-averse company will go under but those that recognise and holistically utilise the ability to skilfully develop novel strategies for survival will succeed where others fail. In Brazil, an employer led initiative and in Argentina a worker led initiative, not without their setbacks, none-the-less faced head-on the economic hazards and succeeded in safeguarding both the companies and the livelihoods of the workforces.

At the operational level the same considerations come into play when determining the requirements for production. The successful strategy is based on the need to achieve the production objectives without causing harms to people, property or the company. Successful productivity is safe productivity and, to put it in evolutionary terms, the successful company survives, is nourished and propagates, as does the successful worker, he survives, is nourished and lives on to propagate the next generation.

And continuing the analogy work has the twin objectives of safely providing the means of survival for the individual (wages and therefore food on the table) and success for the company (quality product, profitability, success in the market). The calculation of the flight distance, or the point at which it is safe to commence the work activity, must aim to achieve each of these two objectives, recognising that an acceptable risk is one that does not conflict with either.

### Risk and hazard assessment

Many workplaces are safer today because of the efforts of workers, engineers, safety professionals, legislators and philanthropists, (with 2.3 million dying each year because of workplace accidents and ill health we cannot assert that work in general has become safer, (ILO 2008)). It is now common in safer workplaces for risk and hazard assessment to be part of good work practices; indeed risk assessment may be regarded as another example of a meme that has replicated successfully and is thoroughly imbedded in the collective mindset. Work activities are assessed to identify risk and hazards and then controls are put in place to safeguard the worker. But this approach is not without its critics and opponents. In the UK, the previous government established a parliamentary committee (WPC 2008)to look into the problems caused by the risk assessment approach, particularly that aspect that led to the profusion of paper based assessments that workers seldom read much less adhered to, and also the claim that ridiculous decisions were being made, e.g. children forbidden to play conkers without safety goggles or councils banning hanging flower baskets for fear that they will fall on the heads of pedestrians, an example of the successful replication of the meme via a variety of outworkings not always beneficial to the vehicle of replication, i.e. people.

(McAleenan P. 2008), in his submission to the Work and Pensions Parliamentary Committee identified that the risk-averse culture prevalent in GB, stemmed from a misinterpretation of the statutory requirements, established in 1974, which had never been corrected over the years. This position remains uncorrected, and now the current government has also established a review and appointed Lord Young to look into OSH legislation to see if it is the cause of such nonsensical decisions (Note: it is more likely that these decisions are urban myths or isolated incidents that feed the sensationalist journalism of the printed media).

Some employers, too, see the safety component of work as an additional cost which can be jettisoned when business is suffering as a result of local or global economic downturn. Unfortunately this occurs when safety is perceived as an adjunct to rather than an integral aspect of worker competence. At the launch of the Seoul Declaration (2008) a number of the platform speakers and signatories highlighted this very point, namely that globalisation and (at that time) the looming economic crisis has serious negative consequences for the safety and welfare of workers, (though it should be noted that for years prior to the economic crisis the annual death toll from workplace injury and ill health was rising from 1.1 million to the current 2.3 million, (ILO 1999 – 2008). Some of these reports stated that aspects of the increase were due to the undercounting of workplace fatalities in the 1990s).

McAleenan and McAleenan (2008) described an alternative approach implemented in a NI government agency in 1997 and developed throughout the 2000s which had been to view production holistically and assess all the requirements for successful production and put in place all that is necessary to achieve this. The underpinning assumption was that every work operation that was not fully controlled was heading for failure, whether in reduced quality or output, plant failure or worker injury. This operation analysis and control approach (OAC) re-integrated safety into the process, into individual competence and also required co-operative effort between the various departments, human resources, finance, production etc. to achieve successful production. Crucially OAC took into consideration worker competence, recognising that the competent worker is one who is fully aware of the hazards and safety issues within his own sphere of competence and capable of assessing and making appropriate decisions with regard to his work activities. This shifted decision making about and control of work operations back into the hands of the worker and the competent team. Superfluous decision makers were removed from the process and those left co-operated in the achieving of the objectives, e.g. production determined the outputs, engineering the competency requirements, human resources recruited and trained competent workers, finance ensured that the activities were adequately resourced and the operational team determined the requirement of and carried out the work operation, (McAleenan and Oloke, 2010).

## Deconstructing risk matrices and control hierarchies

Risk matrices, a common tool in modern risk assessment, utilise two or three multipliers to assign a score and aid the prioritisation of what the worker must do to enable an activity to be declared "safe to start". The standard multipliers are

severity x frequency (of exposure) x likelihood

and in the oil and gas industry this works well when used to determine whether a simple valve closure is sufficient or some tighter control up to the level of breaking the pipeline and inserting a blank plate/spade is required to safeguard workers and property. The danger with matrices is when they shift from being a tool to aid decision making to being the core element of risk assessment and the decision tool itself. The reason for this lies in how the multipliers are interpreted and certain fundamental limitations each has. For example, the severity of outcome multiplier typically has four options, minor injury, lost time injury, major injury and fatality, each scored in ascending order; (there is a variation for property damage). But how do you determine the potential severity of an accident such as a minor cut? In a hospital administration department such a cut may be no more than a minor injury but what would it be in the laboratories, in the ER or on the wards where blood-borne infection could raise the outcome to fatality? Or indeed what if the injured party was a haemophiliac? Would you have different matrices for different departments to allow for this, in which case how would you u se it for the surgeon who sustains the cut in the administration department and then goes down to the theatre? Bangdiwali (2010) describes how in the field of injury research, we often encounter and incorrectly conflate risk and odds and in doing so states "it is not clear how they may differ and how differently they should be interpreted".

Looking at the frequency of exposure, typically the more often the worker is exposed the higher the score assigned. But there is a case for stating that frequent exposure to a hazard aids the competency of the workers and thus reduces the likelihood of injury where-as the occasional exposure to a high hazard activity is likely to result in increased risk of injury through unfamiliarity and lack of sufficient experience to aid competence. And then when the likelihood or probability multiplier is considered, no matter how it is calculated it is incapable to providing one vital bit of information, namely, where there is even the remotest probability, it cannot tell when the incident will occur, and there is no law that states that a 1:1,000,000 probability will not occur on two consecutive instances.

Risk matrices, if they are to be used, must never substitute for a comprehensive assessment of the work activity (not simply an assessment of the risk) and the implementation of the controls necessary for ensuring that the activity is safe to start.

Coupled with the risk matrices is the "hierarchy of controls" table, a typical one being

1. Eliminate/avoid (the risk), and if that is not practicable put in place
2. engineering controls,
3. process controls,
4. behavioural controls/safe systems of work, and finally
5. use PPE.

Viewing controls as a hierarchy has the potential to prevent work activities commencing in the first place as for example banning particular children's games in school or the banning of ladders by some companies (as happened in the UK after the introduction of the Working at Height Regulations in 2005), or to over-the-top controls being implemented in circumstances that would have been equally safe with a combination of other controls. The over utilisation of risk matrices and hierarchies of control contribute to risk-averse behaviour which creates barriers to the work activities or which overly burden workers with unnecessary control procedures and, in the UK, excessive reams of paperwork which only serves to alienate workers from rather than encourage them to engage in safe working practices.

 

## Calculating flight distance

The absolute flight point is that point when a work activity has been deemed by the competent worker/team to be safe to start, in other words when the minimum controls reasonably required to carry out the work activity and achieve a safe outcome are in place. This requires more than simply controlling those hazards that are obviously present, or by commencing the work activity without the necessary level of skill to do so. The competent worker/team will be aware of the intricacies of the work activity including the hazards, apparent and intrinsic, and will know how to prepare for or respond to those which may arise in practice.

But the absolute flight point is not the same as the absolute safe point. It is simply the minimum acceptable condition for commencing work. There often (but not always) remains the risk zone, the zone within which unusual circumstances may arise and which may lead to harm or injury. The optimal flight distance will take into account such additional hazards as are reasonable and put in place additional controls. Lattitude (2007), in the safety film, "All for one – the meerkat way", meerkats will flee at the approach of a predator; that is their absolute flight point. But as the film-makers observed feeding groups will always have at least one of their number on look-out duty. This is a reasonably required additional safety control amounting to an optimal safe situation; they can no-longer be surprised by an approaching predator. They have refined this behaviour to the extent that the warning is not simply at the presence of a predator, but whenever it is apparent that it presents a danger to them, thus a sleeping predator will be ignored, though continually observed.

In human behaviour we act in a similar manner; e.g. in confined spaces entry, all things being equal, the safe to start point is when the air is breathable and will be maintained so throughout the entry. But this is not an absolute guarantee against unforeseen circumstances, hence to the provision of escape sets, the use of a watch-man on the outside and the practice of safe entry procedures, i.e. reasonable additional safeguards that will guarantee a safe outcome, the optimal flight distance.

We have outlined the evolutionary process that has brought us to the point where man is a complex analytical being with extensive capacity for creating novel and effective solutions for any situation that he finds himself in and even for situations that have not yet occurred. It is imperative that there is no emasculation of such intellectual and functional capabilities whenever he is placed in work, i.e. employment. The competent worker and the competent team are fully capable of understanding the operational processes and the controls for carrying out the tasks required of them. And having that understanding they are also competent to make operational decisions and in particular decisions as are necessary to safeguard themselves and others. What is required is that they are fully authorised to make essential decisions, that operations are fully resourced in accordance with their assessments and that all superfluous influences that conflict with the safe and effective operation are removed.

Schematically we can break the process down as per figure 4.

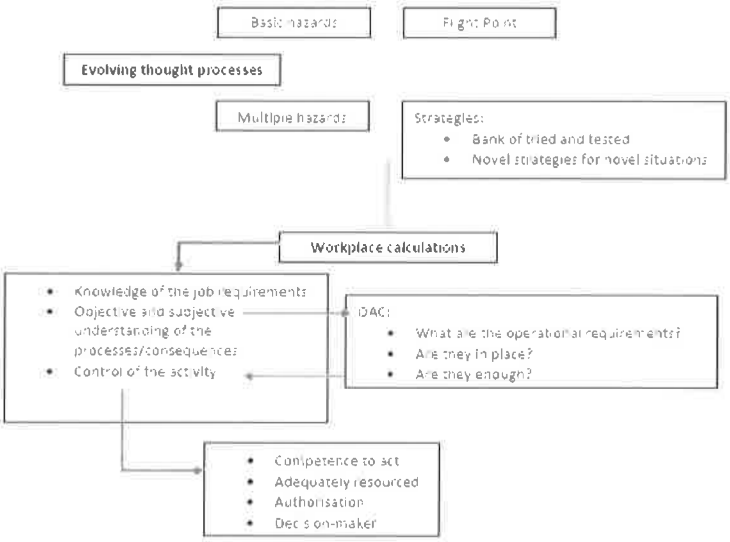


**Figure 4: Decision making process for calculating flight distance**

## Conclusion

This process applies to the individual, the work team and to the company. The success of this process requires that the company recognises that fundamental to work are the twin objectives of workers and the company achieving their respective means of survival, namely a satisfactory remuneration for their effort and a quality product that will succeed in the market. There is no acceptable risk which conflicts with either of these objectives. If the worker is injured and cannot earn or the product if flawed and cannot sell, either or both parties will not survive, the courts will penalise the company for injury to the worker and the market will penalise it for poor product performance.

At the CSSE PDC in 2009 the authors described the competent or mature company as;

> "one where-in the strategy, the managerial structures and polices, and the way in which the company acts to meet its responsibilities towards all the key stakeholders combine in a way that ensures the safety of its workforce and those affected by what the company does, enhances the quality of its output and satisfies the fiscal needs of the owners in a sustainable manner. " (McAleenan & McAleenan 2009).

An evolved company is one that has the intellectual and technological capabilities to prevent workplace accidents and at the same time achieve its objectives without being risk-averse.

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# SAFETY - TURNING THE EVENT INTO A PROCESS: 15 YEARS ON

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## ABSTRACT

*Legislation within the European Union (EU) is driven by directives. Member States are bound to comply with EU directives within a specified time frame. UK legislation has a clear requirement for employers to manage safety and health through the development of valid and effective risk assessments and associated risk control measures. In the USA safety management systems are identified as one of the key elements necessary to meet the goals of the Occupational Safety and Health Act 1970. OSHA's strategy is to pursue the following four strands; Voluntary Protection Programs (safety management system), consultation survey, full-service area offices, and effective enforcement. And while trans-global terminology may differ, the message and the spirit of enforcement remains the same. And yet the evolution of safety created a situation where it became event driven and reactive. This paper discusses how operational analysis and control turned safety back into the process it was intended to be and examines how it developed in the 15 years since it was first introduced in 1996.*

**KEY WORDS** Operation Analysis and Control, Hazard, Control, Prevention.

## INTRODUCTION

Developed in 1996 the Operation Analysis and Control (OAC) methodology (McAleenan and McAleenan 2005) was first introduced to a Northern Ireland government agency with approximately 2,000 employees in 1997. At the time the Agency had six Safety Advisory Officers and a Senior Safety Advisor, hundreds of risk assessments in various stages of readiness and a safety manual that resembled a paper mountain. A widely held feeling at that time was that it was all in the capable hands of the 'safety guys', the inference being that they alone were responsible for ensuring safe and healthy working conditions for their 2000 colleagues. Perhaps this notion stems, in part, from Robens (1972) who, while acknowledging the managers direct operational responsibility for safety and health also discussed the possibility of specialist safety advisors sitting within the line management chain, in much the same way as personnel officers. And while this notion did not find its way through to legislation (HSWA 1974) it nonetheless remained widely held across industry and within the safety professional fraternity. However the Management of Health and Safety at Work Regulations 1999 (and the previous 1992 version of the Regulations) gave effect to Council Directive 89/391/EEC in Great Britain and made clear, what was implicit in Health and Safety at Work etc Act 1974 (HSWA 1974) was that employers are to appoint competent persons to "*...assist him in undertaking the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions...*". The relevant phrase being; "competent person" to assist, not safety officer/ advisor as discussed in Robens (1972) and unfortunately competence and expertise are often conflated; whereas occasionally specific expertise may be needed to solve a particular matter the routine operational analysis and control is well left in the capable hands of competent operatives and managers.

The changing emphasis for the Northern Ireland government agency, post 1997, was an acknowledgement that all its employees, from members of the Board to operatives out on the ground each had capability, resources and the responsibility to ensure safe and healthy working conditions within their sphere of control and influence. To make this transition as smooth as possible safety advisors were gradually reduced in numbers, each assuming a more appropriate role of providing technical assistance when requested by management and staff until eventually when the transition to OAC was complete the safety advisors were phased out. Two requirements were central to the success of this approach were that the Board needed to define their priorities with health and safety integral to their business strategy and they needed to accept that competence is an essential attribute for all employees; noting that competence extends to having adequate resources, responsibility to achieve and the authority to act within their sphere of control. In the first 5 years of operating OAC the lost-time accident levels in the Northern Ireland government agency fell by over 69%. Over the second 5 year period the Board of Directors set new and more challenging lost-time accident reduction targets, which were consistently exceeded. The resultant reduction in the reportable accident rate was more than double the performance target set by the Chief Executive Officer at the time of introduction. The OAC has been audited, using traditional audit techniques each year since it was introduced and 85% to 95% compliance was not uncommon, a testament to the acceptance of the approach across the organisation.

Fifteen years on from it was first developed companies using the OAC model or elements of it examine the requirements necessary for successful and therefore safe outcomes and ensure that the resources; human, material and financial, are in place to control their operations. The OAC approach is expandable from simple everyday tasks to the comprehensive task of governing the organisation. Its effectiveness requires that each functional role has a sphere of control and a sphere of influence.

## BACKGROUND

Robens (1972) in his report, presented to Parliament by the Secretary of State for Employment stated "the first and perhaps most fundamental defect of the statutory system is simply that there is too much law". and in an attempt to simplify the situation recommended a self-regulating system of safety and health provision, where industry and commerce are encouraged to address their own safety and health issues, supported by a single enabling act and a series of appropriate standards voluntary codes of practice. Although much has changed in the socio-economic profile of Great Britain and with it the relevance of the legislation (Walters and James, 1998) the intent of the HSWA (1974), which stemmed from Robens (1972) still has relevance today; Metherall (2010) states "...[it] *is generally considered to be visionary*". The self-regulatory nature of the HSWA is its most vital aspect and as such remains an important direction for businesses, of all types to follow in their effort to achieve improved safety performance, providing it is interpreted and actioned correctly. The European Union (EU) directives of the late 1980's and early 1990's set a legal framework for safety and health legislation across all EU member states. Council Directive 89/391/EEC sets out the principles pertaining to protection of workers and prevention from harm, in a manner not unlike HSWA 1974 (Metherall 2010), which had been established fifteen years earlier in GB. Consequently the requirements across all EU member states are broadly similar. Difference will arise in how each country brings the requirements of the EU Directive(s) into statutes, however the general principles remain the same. Contrary to Walters and James' (1998) belief that the HSWA (1974), and Robens (1972) has relevance only to larger corporations with access to workers representation the intent is clear in Robens (1972) and HSWA (1974). Robens (1972) clearly outlined the committee's belief that workers "*...must be able to participate fully in the making and monitoring of arrangements for safety and health at their place of work...*" and these recommendations became part of statute (HSWA 1974) and later in Council Directive 89/391/EEC. However the legislative framework in GB and EU could have been worded more strongly than the 'workers right to be consulted', since this phrase can be open to interpretation and at the worst case could be taken to mean 'told'. Such an interpretation negates the Council Directive's requirement for "*balanced participation*". Furthermore one of the three paradigms in the Seoul Declaration (ILO et al 2008) is clear; "*Occupational safety and health is a common responsibility taken on by every societal player rather than just by the government, employers, or OSH institutions*".In the USA the Occupational Safety and health Administration (OSHA) maintains that the employer has the statutory duty for decision-making however in its commentary on its safety and health program management guidelines it clarified that although its intends that employees do not make safety and health management decisions but that "*...they* [are to] *be included in the process on decision-making on matters which affect their health and safety*" (OSHA 1989). Ayers and McAleenan (2008) identified that the process of worker consultation is an mandatory aspect of the Occupational Health and Safety Act 2004 (in Victoria, Australia), positing that taking into account Australian statutes as well as other legislation and standards across the world the natural conclusion is "*...that real and meaningful consultation between workers and management is not only desirable but essential*". The International Labour Organisation (ILO) require that employers have access to sufficient competence to identify and eliminate or control work-related hazards (ILO 2001). Corcoran (2011) describes an initiative on the £130m tunnel project in Belfast N. Ireland, where direct management and worker engagement turned around a significantly high accident frequency rate, reducing it by over 60% in a year where regular and relevant discussions between and actions taken by workers and managers proved that a positive safety climate can produce positive results.

The core legal requirement therefore, and this applies globally is that employers provide workplaces that are free from recognised risks that could cause death or physical harm to employees (McAleenan and McAleenan, 2002), and that employees are properly engaged in the process of establishing the appropriate hazard controls. Ayers and McAleenan (2008), in discussing consultation suggest that a natural extension of consultation and for that matter balanced participation (European Community 1989) is workers' engagement with hazard identification and the establishment of effective hazard controls. And this point is explored further by McAleenan and McAleenan (2008) where it is argued that building a sustainable business cannot happen where old style safety professionals take charge of safety matters while the real work is being carried out by the general workforce. This has the opposite effect, compromising safety by removing key aspects of the control of the operation from the workers, effectively neutering their ability to safely produce the end product. Acknowledging that workers are competent and ensuring that they remain so is a central to a company having the ability to establish safety as a process within their organisation. And that recognition has to extend beyond the normally accepted idea of training/ education and experience. In the Irish Supreme Court ruling in 1977 in the case of Dalton v Frendo it was held that having due regard to the age, skill and experience of a worker, he or she will know the hazards associated with their work and be able to apply the controls necessary to prevent harm. Thus it is established that the ability to work safely is an integral aspect of competence and needs to recognised as such in the execution of safe systems of working. A competent worker is skilled, authoritative and in control of his work (ISSA 2003, ILO 2005, ANSI/AIHA 2005, McAleenan and McAleenan 2008, Ayers and McAleenan 2008).

## SIMPLE NOT SIMPLISTIC

Much has been discussed lately (Young 2010, McAleenan 2010a) and indeed it is the subject of review in UK being undertaken by Professor Lofstedt (DWP 2011) about over interpretation of safety regulations in GB, yet it is more correct to discuss this as misinterpretation or misrepresentation. Young (2010) presented a report to UK Parliament which among other things presents an attack on over-regulation with respect to safety and health; a failure on his part to recognise that he was furthering a 'tabloid' myth. His findings have been disputed (Hansard 2010) when Lord Jordan, President of ROSPA stated;

> "*...the [Young] report is very strong on measures to deal with some unprincipled and greedy members of the legal profession, it has three major health and safety weaknesses: a lack of professionalism, a lack of in-depth understanding of health and safety, and a general lack of balance...*".

Although criticised at home and abroad the Young report (2010) spawned the Lofstedt review (2011), which is currently gathering evidence as part of a review into "*...the opportunities for reducing the burden of health and safety legislation on UK businesses whilst maintaining the progress made in improving health and safety outcomes*". The review is due to be completed in Autumn of 2011. McAleenan (2010) set about dispelling the myths and misinterpretations that have been promulgated over the years pointing out that terms such as 'written risk assessments', 'significant risks' 'risk matrices' and 'hierarchies of control' are largely misinterpretations of the law by those who should know better. Over time, if no-one ever goes back to source a misinterpretation becomes a generally recognised position leading, eventually to a rash and incorrect generalisation of what the law requires. For many employers the safety and health advice they receive is presented in this fashion and it is often only stripped back down to the exact legal definition/ requirement when it comes into the prosecutions arena; much too late. For GB there is a possibility that Lofstedt's review (2011) will serve to redress this imbalance across industry and the various professional bodies.

The fundamental legal obligation is the creation and maintenance of a safe and healthy working environment and the production/ delivery of a product or service that does not present harm to the worker or the end-user. The second paradigm in the Seoul Declaration (ILO et al 2008) refers to the 'prevention culture' indicating that "*...it needs to be supported and sustained by shaping and implementing OSH policies, strategies and programs fully reflecting preventive measures*". Central to all of this is the recognition that competent workers participate fully in the safe delivery of that product or service. Accepting these it is possible then to work within the parameters of current legislation and guidance, in a meaningful and straightforward manner. At the outset OAC, several years prior to the declaration at Seoul, distilled the legal requirements into a distinct and workable solution for businesses of all sizes and complexities, relying on the opportunities presented by a competence and properly resourced workforce. Fundamentally risk assessment, referred to in many jurisdictions is a process, not a product. Specifically it is the thought process requiring the involvement of the right people and the implementation of necessary control measures. "*The critical feature* [for any work activity] *being that prevention is fundamental and that work activities must be safe to start, safe to execute and safe to finish*" (McAleenan 2010). The USA's safety management standard ANSI/ AIHA Z10 (2005) states "*...safety responsibilities must be recognized as a part of each job at every organizational level*", while the principles established in the Quebec City protocol (ISSA 2003) include that "*...OHS competencies associated with each step in the performance of a task be integrated into the educational process for a given occupation*". That and the recognition that effective responsibility cannot be separated from the authority to make decisions is the kernel of the OAC approach, characterised from the outset by three questions; What can cause harm? What is being done to prevent the harm/ protect the workers? and Is enough being done?, the final question delivering the continuous improvement element, necessary if we are to keep going forward with a zero harm agenda. Maharaj (2008) suggested that "*...on a practical level, safety conscious managers and directors are able to motivate employees of a company to improve the level of safety performance associated with their work*". And in that regard the effectiveness of OAC comes from its management led/ worker driven approach.

## RIGHTS and REASONABLENESS

The OECD Principles of Corporate Governance (2004), from which came the UK Corporate Governance Code (Financial Reporting Council 2010), the outworking of which have far reaching connotations. Critically for the field of safety and health is the recognition within the Code that governance applies to stakeholders and not just share holders, which implicitly gives employees a reasonable say in how companies are run, particularly when they are affected by the companies actions and/or decisions. The Seoul Declaration (KOSHA 2008) added further weight to the discourse when it stated "*...the right to a safe workplace should be recognised as a fundamental human right*", making worker safety and health a 'rights' issue linking it firmly with the United Nations Declaration on Human Rights (UDHR 50 1998). In 2005, in a further development of the OAC model, the concepts of rights and of reasonableness were introduced to the 17th World Congress on Safety and Health at Work, that is 'duty of care' as a fundamental was explored (McAleenan and McAleenan 2005a). Winfield (cited in Horsey and Rackley 2009) argues that duty of care is too all encompassing to have meaning in the real world and may well be a superfluous principle since cases before the courts may be decided on grounds that do not depend upon duty. The argument being that in statute law duty has been sufficiently quantified to the point where it is limited to practical considerations. The concept of reasonableness comes into play in determining whether acts or omissions leading to the death or injury of an employee or member of the public was the result of a failure to take reasonable care (aka negligence). It is important to remember that the law only requires us to act carefully sometimes and as such we are not always automatically liable for the consequences of negligent acts. In the exercise of OAC within the workplace the expectation is that all reasonable avenues will be explored to ensure that a work operation is safe to start or a product is safe to leave the premises.

It is not just the legal position driving the reasonableness in safety and health agenda. Discussing her early career thoughts on International Workers Memorial Day Benay (2008) stated "*...I thought being an effective safety professional meant addressing common workplace hazards and repeating compliance requirements at the health and safety committee meetings*". However as Benay's experiences grew it became obvious that there was a clear human factor to safety and health interventions way beyond books and strategies and that if those factors were not adequately addressed then any amount of available paperwork would effectively be worthless (Benay 2008). The reasonable company taking the right approach will do what it takes to further the 'zero harm' agenda and to continue doing so until it has been achieved. In recognition of that and in a clarification of the debate that often surrounds productivity vs safety McAleenan and McAleenan (2010b) introduced the notion of the twin objectives. That is where "*...worker safety (survival of the individual) and profitability (survival of the company) co-exists*". A risk that conflicts with either one of these objectives is a risk too far. And in developing the strategic thinking in this direction a further strengthens the efficacy of OAC and and the safe to start motif. There is no room in this approach for the over-zealous, misinformed safety advisor or manager to produce or insist upon an unreasonable or unworkable solution. Those who deliver expert assistance, if required by the competent worker, and who adopt this strategy will find that they are closely aligned to the statutes and international protocols and that their worth to the organisation greatly enhanced.

## THE CASE FOR EDUCATION

The world of work is safer today as a result of interventions from educated workers, engineers, safety professionals managers who are enlightened and persistent in the pursuit of safer and healthier working conditions, however the record of 2.3 million workplace deaths annually (ILO cited in ISSA 2008) is a clear indictment of the failure to fully embrace what is required to achieve zero harm in the workplace. An area renowned for its high level of workplace accidents and ill-health is the UK construction industry and as a consequence of the review of existing and the introduction of revised construction design and management regulations it was possible to develop the OAC theme into design safety analysis. The now well established mantra in construction; namely that designs should be such that they can be built, used, maintained and demolished without causing harm to workers or users was first coined in a consultation response to UK's Health and Safety Executive (McAleenan and McAleenan 2005b) and is now enshrined in the Approved Code of Practice in the UK. In Melbourne in 2009 the audience at the CIB W099 conference was challenged to embrace the notion of inherently safer designs, an idea already well thought out in the process industries. Within days the idea was being discussed on Melbourne construction sites with the workers in turn challenging the designer to show inherent safety in their 'at height' work requirements. This particular iteration of OAC relies upon the same guiding principles as the original and also upon a well educated design professional.

Quebec City Protocol (2003) summons educators to integrate "...OHS into vocational and technical education..." Phillips (2009) cites and praises the American Society of Civil Engineers' championing of the ExCEED (Excellence in Civil Engineering Education) programme in its approach to improving the teaching capabilities in order to considerably enhance the students learning experience. Stacey, Simpson and Schleyer (2009) discussed the means for ensuring that "*...safety-critical professionals received adequate education in health and safety risk management*", citing Lord Cullen at the Hatfield Rail Enquiry *"Education of engineers should deliver professionals who understand their professional responsibilities for the safety of the public, including the need to act on safety critical defects, and who can apply the principles of risk management."* O'Brien and Hill (2009) described an innovative approach where post graduate architecture students were required to build their designs, firstly on campus and laterally on site in a third world country. The idea behind the programme is to allow the designers to engage with the tools and learn, from first hand experience the safety and health issues. Once they had mastered this on campus the third world experience tested their ability to adapt and work within the ethos and constraints of local resources in remote and poor communities and in the process of working with local labour to enhance their teaching skills, an attribute necessary in a construction professional. O'Brien and Hill's (2009) approach was a more hands-on version of the ExCEED programme described by Phillips (2009). In pedagogical terms, Marton (1981), cited in Biggs (2003) resurrected the term 'phenomenography' to describe that the learners perspective determines what is learnt and not specifically what the educator intends the learning outcome to be. Thus if each learner is individual and with many learning styles it must also hold true that each educator is also an individual and that both learning and teaching styles are many and varied. Freire (1973) talked about educators having to think in terms of 'teacher-student' and 'student-teacher'; that is, a teacher who learns and a learner who teaches as the basic roles of classroom participation. Freire (1973) also insists that educator and learner are not on an equal footing, but that the educator must be humble enough to be disposed to relearn that which he/she already thinks they know, through interaction with the learner. In that regard whether education is through formal processes or more the informal mix of short courses and work-based learning and whether the learner/ educator roll is played out by worker/ employee or student/ teacher the rationale remains and he concept of life long learning as a 'way of life' is how it should be. This taken on board alongside Marton's (1981) concept of phenomenography is what is needed to drive safety and health education forward. In the foreword to EUOSHA's document of mainstreaming OSH into university education (Copsey 2010) the Director states, "*...if OSH is truly to become an integral part of business management in all sizes of organisations then all future managers and professionals need relevant* [*risk*] *education, not just those who work in high risk sectors*". Copsey (2010) describe 36 good practice example cases across the European Union where OSH education has been embedded in the curriculum. The examples span many professions, including architecture, medicine engineering and business administration.

## CULTURAL MATURITY

The third and final paradigm in the Seoul Declaration (ILO et al 2008) states;

> *"occupational safety and health requires a fundamental conceptual shift towards the creation of a culture enhancing workers' well-being and welfare, away from a myopic focus on responsive accident-prevention activities"*

IN recognition of the third paradigm McAleenan and McAleenan (2010b) concluded that "*An evolved company is one that has the intellectual and technological capabilities to prevent workplace accidents and at the same time achieve its objectives without being risk averse*". McAleenan and McAleenan (2009) had previously discussed the link between competent companies and cultural maturity, in the context of the Seoul Declaration (ILO et al 20008). Up until then OAC never had a specific audit tool since it is not some new management system to sit atop all other management systems, rather it is an approach or thought process which readily integrates with whatever management style exists in the company it is flexible enough to adapt to any style and robust enough to stay the pace. Once embedded in the company it can be measured against any of the international management specifications; quality, environmental or safety; including ILO-OSH 2001. However the present discourse, associated with the third paradigm, took OAC to another level and to the refinement of a pre-existing diagnostic tool (McAleenan and McAleenan 2009) to allow it to address organisational cultural maturity. Delving into the intent behind the third paradigm and exploring some of the relevant definitions the following holds true. A competent company is one where-in the strategy, the managerial structures and polices, and the way in which the company acts to meet its responsibilities towards all the key stakeholders combine in a way that; ensures the safety of its workforce and those affected by what the company does, enhances the quality of its output, and satisfies the fiscal needs of the owners in a sustainable manner. Culture is the way in which the company behaves with respect to critical factors such as safety, sustainability and stakeholder rights, and the structure is the way in which it organises itself to achieve its objectives. Quality companies demand exemplary work practices and excellent conditions throughout and in order to obtain these assess how competence is viewed and practiced. Cultural maturity is when a company demonstrates that it has the necessary attributes essential to achieving success in health and safety, productivity and meeting its obligations towards all its stakeholders. However in Seoul (ILO et al 2008) and with the emergence of behaviour based safety (BBS) interventions as a management tool there was clearly a need to create a diagnostic tool that would allow companies to measure the success of their programmes while they are developing, not at then end by calculating the accident frequency rate and comparing it with pre-intervention levels. These kinds of measurements have traditionally been the favoured approach because they are considered tangible and anything associated with human behaviours such as BBS interventions are deemed to be intangible.

The diagnosis of organisation cultural maturity described in McAleenan and McAleenan (2009) is a thorough examination of leadership roles, responsibilities and actions measured against the policies and practices within a organisation providing a tangible measure of what is normally considered to be the intangibles in the management system. This approach brings the focus onto the positive effects of both the tangible and intangible activities of an organisation and the measurement is in the form of a leading indicator, measuring successful interventions and activities as they occur.

**15 YEARS and now?...**

The OAC approach has been consistently based on the premise that work activities must be viewed and carried out holistically with no unnecessary separation and devolvement of functions to others, particularly in the realm of critical decision making vis-a-vis safety. Since the 1990s environmental responsibilities have in some considerable areas been devolved to the health and safety departments, as too in some companies quality. It is not uncommon to see the acronym HSEQ to describe the role of the safety practitioner. In parallel with the increasing social and political awareness on environmental matters has been the developing concept of sustainability, once associated with environmental sustainability it now often explores the issue of business sustainability. Behm (2009), asked whether any industry that kills and injures its workers can be realistically called a sustainable industry, thus integrating the quality of workplace conditions with an ethical stand on whether the business should much less could be sustained.

As the OAC approach was been introduced to businesses it was being refined via regular presentations to gatherings of professional bodies; safety, construction, engineering and academic. Each refinement was a logical development of preceding concepts, commencing with the holistic approach to workplace safety, through the application of the principles of effectiveness to work management, to the rational re-integration of responsibility and authority to make decisions related to the work being undertaken. In the process it has become apparent that realistic considerations of work activities must see them in context, not simply of their relationship to other activities on the shop floor or construction site, nor indeed of their context within the overall company in which they occur, but also in the context of their wider impact on social and environmental matters, locally, nationally and globally. The twin objectives for the sustainability of any business is for its activities to be good for the individual worker and good for the company and in this we have echoes of Fromm's (1947) contention that what is good for the individual must of necessity be good for humanity. At the 2008 World Congress in Seoul it was reiterated that safety and good health at work was a fundamental human right enshrined in the UDHR, but delegates were also warned of the negative impacts that globalisation and the then impending recession would have on the safety and health of workers and on the communities from which they came. As the leading employer, worker and government bodies come together to seek ways and means of eliminating the annual workplace death toll of 2.3 million in other arenas and educational institutions discussions and activities are exploring ways in which Fromm's case for a science of humanity to be a core component of all educational and professional development. In this a well educated worker in considering what is good for him in the context of his work activity will also be considering how that good meets the needs of his fellow man. The next step in the development of workplace culture centres not solely on whether a worker goes home as safely and as healthfully as he arrived that morning, but on how the culture of the workplace contributes to the overall benefit of society.

"*Every human practical activity derives its value from its efficiency as a means to that end [human happiness], it is good or bad, right or wrong, as it conduces or fails to conduce to Happiness*". Aristotle.

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# Methodology for the evaluation of qualitative factors in safety culture

Workplace tasks and activities often have objectives that do not lend easily themselves to evaluation by standard measurements. OSH is a case in point where in objectives may be set in negative terminology relating for example to the reduction of accidents, absolutely or by percentage. These can be quantitatively established and measured. But when it comes to establishing qualitative objectives these are often set in terms of intangibles, such as improvements to the quality of performance, of output or customer satisfaction. Whilst the quality of a hard product may be measured against specific and universal standards which are quantitative, the quality of performance of workers and work-teams does not lend itself so easily to agreed/universal quantitative standards and therefore to objective evaluation.

Once such area that presents particular problems is that of safety culture, not least because of the widely differing interpretations on what it is. However in the adoption of a praxic approach where-in a common agreement is arrived at as to what constitutes a safety culture and a commitment to strive towards achieving/improving increased maturity it is possible to evaluate and score the safety culture of a company in a manner that is reiterative and consistent.
By establishing the maturity criteria and a set of core competencies necessary to measure each criterion it is possible to evaluate and compare the objectives of the company, the activities of management and the performance of the workforce in practice and produce a rating and an action plan for improvement. The process is objective, capable of reiteration year on year, across departments and indeed across an industry, allowing for benchmarking and continuous improvement in safety.

## The Competent Company

The concept of the competent company is one where-in the strategy, the managerial structures and polices, and the way in which the company acts to meet its responsibilities towards all the key stakeholders combine in a way that ensures the safety of its workforce and those affected by what the company does, enhances the quality of its output and satisfies the fiscal needs of the owners in a sustainable manner. What is required is the establishment of a competent and sustainable industry, achieved through commitment at all levels in the industry, which means that companies and their clients work in partnership within the industry, the health and safety enforcement agencies, fellow client bodies and workers and their representatives, Board members' commit to making safety work for all their staff and for all those affected by their work,
Business strategies and objectives are prefaced with a commitment that goals will be achieved in a manner that does not cause harm to workers or end-users, Companies go beyond compliance where OSH is critical, and Individuals, workers and employers will act as they would expect others to act, i.e. competently.
The culture is the way in which the company holistically behaves with respect to critical factors such as safety, and the structure is the way in which it organises to itself to achieve its objectives and goals. There are two primary elements responsible for the effective governance of the organisation, namely the Board (or its equivalent) and Management. The former is accountable to the stakeholders, is responsible for the strategic direction of the company in the attainment of the corporate objectives, including the setting of those objectives. The management is responsible for the day-to-day activities that are necessary for the setting and achievement of interim targets that go towards meeting the strategic objectives; they ensure that the objectives of the company are met in a manner that is effective and non-injurious. It is essential that these two elements are aware of and work within their respective roles such that there is no superfluity of function that permits the one to overlap significantly with the other, thereby negating, or at best severely restricting the functionality of both.

## Cultural Maturity

It is not uncommon for the safety practitioner to audit the safety culture within the companies in which they are employed or engaged. Quality companies demand safe work practices and healthy conditions throughout and in order to obtain this begin with an assessment of how safety is viewed and practiced within. Often this is conducted via attitudinal surveys and supported by observations of practice. There is a tendency for this approach to admit to a high degree of subjectivity, particularly in the absence of universally accepted criteria for determining what constitutes culture and how it may be objectively measures and compared against other companies, or indeed between departments within the company.
In developing and implementing Operation Analysis and Control (OAC) processes within a company there are a number of core criteria the absence of one or more of which will severely impair the company's sustainability in times of economic crises and which impact negatively on its ability to remain viable relative to competitors in times of economic stability. These are;

**Corporate Social Responsibility (CSR):** wherein competent company is aware of and acts to meet its responsibilities towards the key stakeholders, including society, customers, community, workers and owners,
**Innovation:** the company ihas the ability to diversify and transfer skills to the development of new products and outputs,
**Resourcefulness:** the company can use existing human, material and financial resources in a creative and adaptive manner to meet the challenges of changing social and economic conditions, and
**Authority:** the company encourages self-managing units where-in individuals and teams have the authority to make decisions within the sphere of their control and influence.

## Organisation Cultural Maturity Index (OCMI)

Having identified these criteria the task was to design a way to objectively assess how a company demonstrates that it possesses the cultural attributes essential to success in establishing preventative measures in respect of occupational safety and health. The challenge is to put in place a system that will measure and monitor an organisation's behaviour and competence and present the findings in a consistently objective manner. The Organisation Cultural Maturity Index is a tool kit that will measure the policies and practices within a company and calculate a score that will place the company on a maturity rating.
The OCMI, once the weighting of the maturity criteria have been established, when consistently applied year on year objectively compares the growth in cultural maturity of the company and can be applied to specific aspects of the company (such as; OSH, Finance, Governance) or to sections of the company, and similarly will allow objective comparisons between these sections.
The index, displaying the year on year scores across all criteria for all the core capabilities of the company, provides the information necessary for the establishment of both strategic objectives and managerial targets, from which action plans may be developed.
The safety practitioner, being well versed in prevention requirements can utilise this toolkit in much the same way that they would conduct safety audits for their employer or client. Moreover the OSH Professional as a safety strategist is well placed to persuade and lead the company through this process towards a growing maturity.

| Company Name: | | | Company Contact Details: | | | | |
|---|---|---|---|---|---|---|---|
| | | | Maturity criteria for a competent company | | | | |
| Core Capabilities *(in respect of Safety Culture)* | CSR | Innovation | Resourcefulness | Authority | Score Avg =Sum(b:e)/ | Weighted multiplier | Multiplied score |
| Leadership | 6 | 8 | 4 | 1 | 4.25 | 10 | 42.5 |
| Collaborative Working | 9 | 6 | 5 | 9 | 5.75 | 5 | 28.75 |
| Working Safely | 6 | 3 | 2 | 8 | 4.75 | 10 | 47.5 |
| Using Management Standards | 5 | 6 | 7 | 8 | 6.5 | 5 | 32.5 |
| Developing People | 8 | 7 | 6 | 5 | 6.5 | 8 | 52 |
| Managing Operations, Project Controls | 3 | 2 | 4 | 8 | 5.25 | 5 | 26.25 |
| Reporting Effectively | 6 | 7 | 8 | 5 | 6.5 | 10 | 65 |
| Incentivising Behaviour | 7 | 3 | 2 | 8 | 5 | 5 | 25 |
| Defining Objectives | 8 | 6 | 7 | 8 | 7.25 | 8 | 58 |
| Setting & Managing Budgets, Establishing human/material/financial resources | 5 | 7 | 6 | 5 | 5.75 | 5 | 28.75 |
| | | | | | Totals | 71 | 406.25 |
| | | | | | Maturity Rating | | 57.22 % |

These Core capabilities examples relate to the evaluation of the safety culture in a company.

This company has an OCMI rating of 57.22 for Safety Culture.

Expert Ease

## The Core Capabilities

The core capabilities are those capabilities deemed necessary by a company for the effective management of their business and successful production and delivery of products and services to their customers whilst meeting their legal and social obligations to the workforce and the public and their fiscal responsibilities to the owners of the company. In this example 10 capabilities relating to the safety and health culture have been selected for demonstrating the model. These are:

**Leadership**
**Collaborative Working**
**Working Safely**
**Using Management Standards**
**Developing People**
**Managing Operations, Project Controls**
**Reporting Effectively**
**Incentivising Behaviour**
**Defining Objectives**
**Setting & Managingl Resources**

These capabilities will be assigned a weighting by the company in accordance with the degree of importance in achieving the company's strategic objectives or by a set of principles that is consistent and justifiable. Ie.g the following principles are used:

**Legal requirement**
**Strategic objective**
**Managerial requirement**
**Operation necessity**

The core capabilities are then measured against the each of the maturity criteria utilising a set of questions designed to elicit information from a representative selection of senior staff and employees, and to gather material evidence that will substantiate the assessment conclusions.

| | CSR | Innovation | Resourcefulness | Authority |
|---|---|---|---|---|
| Leadership | [illegible] | [illegible] | [illegible] | [illegible] |
| Collaborative Working | [illegible] | [illegible] | [illegible] | [illegible] |
| Working Safely | [illegible] | [illegible] | [illegible] | [illegible] |

Assigning a score to the information and evidence gathered is based on an objective determination of the knowledge held and ability to act on and manage the operation or procedure of the people within company or the department that is being assessed. The determination of the assessor must be reasonable and in line with what another person competent to conduct such an analysis would make.
The assessor would be guided by standard audit practices and methodologies ensuring the objectivity of the process and permit independent verification of the evidence and scoring.

ocmi

# Enhancing Ethical Reasoning in Design Education

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**Abstract**

**The art of engineering is founded upon the science of physics and maths. In and of itself good design is that in which the constructed project tends towards achieving functional excellence. Conversely bad design tends towards its opposite and the structure will fail to meet its objective.**

**Green and sustainable design has emerged from ethical considerations about what is good for the environment and ultimately what is good for humanity. However when it comes to ethical design the values which guide the designer are founded in codes of practice and conduct which appear fixed and stemming from higher (professional) authority rather than from an objective science. This paper makes the case for the inclusion of a science of humanity in academic and professional studies as the foundation of the art and practice of ethical design. By understanding what human nature is and how we make determinations about what is good (and bad) for ourselves and others we can develop an ethical approach to what we design and build. As with good engineering or sustainable designs ethical design tends towards the construction of projects that are good for humanity in a holistic sense.**

**Keywords**

**Prevention Culture; Well-being; Ethics Reasoning; Human Rights; Responsibilities**

## Background to Ethics

Ethics at the beginning of the 21st century are informed by a number of theoretical and philosophical traditions concerning what it is to be a moral person. Of these there are three broad traditions that encompass various philosophical perspectives which stand out as dominant in their influence. This summary will not do justice to the merits of these great traditions being as they are but an outline of the current strands of moral reasoning.

### Virtue ethics

Virtue ethics stems from the earliest period of classical thought and includes the works of Plato (Rouse, 1956, and Lee 1955) and Aristotle (Thomson 1953). Simply described, ethical behaviour is driven by the character of the individual who, in holding certain values to be virtuous acts in a manner that will enhance his virtuousness, e.g. where honesty is a virtue he will always act honestly and thus be more virtuous as a consequence. Conversely, any instance of dishonesty on his part negates not just that characteristic (honesty) but his general standing as a virtuous person. Virtue ethics can apply to a corporate body in a similar manner and what is considered a virtue the body and all its members are driven to act to enhance that virtue and its own virtuousness. However a difficulty with virtue ethics is that "virtues" are subjective and there are many obstacles to universalising them including the fact that not all virtues are agreed upon nor their essential nature having universal acceptance.

### Deontological ethics

Deontological ethics is based on rules and ones a duty to adhere to the laws and conventions of society or the group that they profess membership of. In this the rightness of the act is based on whether it is according or contrary to the rules and duties imposed on the individual or body carrying out the act. Leading deontological thinkers include René Descartes, Gottfried Leibniz (Russell, 1900) and Immanuel Kant (Körner 1955) the former advancing a theory of Divine Command which in religious terms an act is right if God deems it to be right, whereas Kant, who was influenced by Leibniz, argues that acts are morally right when carried out from a sense of duty to act in ways that are good with the proviso that that which is good is intrinsically good. Difficulties with deontological ethics arise when the moral agent is confronted with a requirement to act but which ever action he takes will result in a breach of the rules. E.g. a prohibition against killing, which includes the requirement to prevent killing when it is within their power to do so places the moral agent in a paradox when in order to prevent a greater loss of life in war he must accede to war; if we go to war many people will be killed and if we do not go to war many with still be killed by the aggressor.

### Consequential ethics

Consequential ethics judges the rightness of an action by its consequences; a good outcome means the act was good. Utilitarianism is one form of consequentialism and one version of utilitarianism is based on the principle of "the greatest good for the greatest number". Other versions include a hedonistic ethic based on the greatest happiness or the greatest pleasure principle. In respect of the greatest good element the example above means the going to war becomes a good act if it prevents an aggressive war and results in fewer lives lost. However problems arise with this perspective if one considers that one bad act may be considered permissible in order to achieve a greater good, after the fact. It becomes a question of what limits or constraints there are to such actions. This allows an "ends justify the means" morality but as the ends cannot be known until after the means have been executed the means remain in a Schrödinger-like right and wrong state until the outcomes are assessed. And without constraints all acts are thus permissible if the intent is good, though the judgment comes later. It is argued that no matter what the intent some acts are neither just nor permissible either in law or because they are so contrary to what it is to be human that they are abhorrent (Green 1881).

Whilst these theories all have their distinctions, in practice moral agents develop ethical reasoning using principles from all these and other traditions, e.g. the Nolan Principles in the UK are in one sense based on virtues of what a good public servant should be but then they codify the duties of the public servant. As the duty is to the welfare or benefit of the public they also draw on utilitarian principles too.

## Ethics in the Prevention Culture

Article 23 of the Universal Declaration of Human Rights (UN General Assembly 1948) states, "*it is a basic human right for everyone to have just and favourable conditions of work*", the signatories of the Seoul Declaration (2008) interpreted this to mean a safe and healthy working environment. This is one of its two fundamental propositions (McAleenan 2008). In adopting the Seoul Declaration a series of new paradigms were provided in respect of occupational safety and health (OSH);

> OSH is a common responsibility assumed by every player in society;
> It shifted the fundamental concept from just focussing on accident-prevention activities to the creation of a culture enhancing workers' well-being and welfare; and
> It creates a new concept of a "Prevention Culture for Safety and Health" through forming and implementing preventative measures reflected in OSH policies, strategies and programmes. (McAleenan 2008)

At a time when 2.3 million workers are being killed annually as a result of workplace accidents and disease and 430m more suffer injury and ill-health can there be any question that the intent and propositions of these declarations are anything but appropriate and correct?

The answer is less obvious than would appear and in practice the continuing annual death, injury and illness toll would point to a non-acceptance of, certainly a non-compliance with some if not all the key points contained within the declarations. Corazon de la Paz, President of the International Social Security Association (ISSA) addressing delegates to the XVIII World Congress of Safety and Health at Work described globalisation as "*a race towards increased productivity at a cost of reduced safety and quality of work conditions*", (cited in McAleenan 2008). This was echoed by Juan Somavia, Director General of the International Labour Office (ILO) who referred to the "*unfair rules that emerged with economic globalisation*". Nor were failures in workplace safety laid solely at the feet of global corporations; governments came in for criticism from de la Paz who highlighted the fact that 80% of workers are working without adequate social security protection. Such views did not have full support from signatory organisations with dissention and contradiction coming from Antonia Peñalosa, International Organisation of Employers (IOE) who, contrary to ILO annual reports, stated that "*there were fewer accidents, as well as more work codes and better technology*" (cited in McAleenan 2008).

The Seoul Declaration (KOSHA 2008) states that "*the right to a safe workplace should be recognised as a fundamental human right*". This assertion can be viewed as having evolved from the work of the National Co-ordinating Committee (NCC) for UDHR50 (1998) who described human beings as having "*an innate sense of fundamental rights and freedoms that belong to us*". In that respect the sense of safe working conditions as being of intrinsic value, and therefore a matter of ethical necessity, has its roots in human consciousness and awareness of individual and collective well-being. Prevention of accidents is thus an ethical matter not least because it is wrong to have conditions that kill workers but also because the absence of activities and intent to prevent them runs counter to what it is to be human. Fromm (1947) states that "*the sole criterion of ethical value being man's welfare*" and materially the principles of good and evil are distinguished by what is good for man and what is detrimental to him.

## Ethical Responsibilities

In the sphere of European construction the players are defined in statute (Eur-Lex 1992). In the UK and Northern Ireland (NI) the respective H&S laws place duties on employers and employees, and the Construction, Design and Management Regulations (HSE 2007) (CDM) specifies the duties for clients, designers, contractors and co-ordinators. Whilst these duties are focussed on the protection of workers and visitors to construction sites they are not limited in that respect. Construction projects must be undertaken with due consideration given to the whole-life of the structure; they are to be designed in a manner that ensures that they can be built, used, maintained and demolished in a manner that is non-injurious to workers and those who would use it (HSE 2007).

In this regard UK and NI statutes begin to knit with the Organisation for Economic Co-operation and Development (OECD) Principles of Corporate Governance (OECD 2004). Emerging from the principles were regulations and codes in various countries such as the Combine Code in the UK which later became the UK Code of Corporate Governance (FRC 2010) and the Sarbanes-Oxley Act 2002 in the United States.

The outworking of the principles saw several consequences not originally intended but subsequently embraced by the OECD, namely the adoption of the principles by non-financial sector companies, businesses and not for profit organisations who saw that benefits would accrue from organising their activities in accordance with the principles and the widening of the application of the principles to cover matters other than financial regulation. That is the principles guided companies on the overall governance of their organisations, (OECD 2004b). The consequence being that key stakeholders; as distinct from shareholders, now had an opening and a say in how companies were run, particularly when they were affected by the decisions and actions of the company.

Orr (2007) in his presidential address to the Institution of Civil Engineers (ICE) put ethical principles at the core of engineering professionalism. Integrity is at the heart of what engineers do and this involves responsibilities to clients, employers and the public at large taking precedence. Thus integrity is not limited to engineering competence and the recognition of personal limitations but it includes the ability to recognise and counter corruption whether it is in the delivery of less than what was paid for or in the accepting of financial inducements. Integrity also includes acting in the public interest at all times especially in regard to structural safety, sustainability, climate change and the global impacts of local actions.

Such thinking on the role of the engineer is not new. Henry Palmer's inaugural address to the ICE (1818) placed the engineer between the philosopher and the working mechanic (Armstrong et al. 1999) whilst James Laurie first president of the American Society of Civil Engineers (ASCE) strove to embody the ethics of the engineering profession, which had a responsibility to represent the public interest in National affairs (ASCE 1991). If we accept this then, according to Armstrong et al (1999) "*the true professional needs and retains the freedom to act in accordance with personal judgment, unbiased by the overriding needs of his employer*".

The importance of ethical codes as a factor in safety performance is recognised by researchers into workplace safety (Kapp and Parboteeah 2007), who, while asserting that no previous work has examined the relationship between ethical climate and safety related behaviours found that there was a string correlation between the organisation's principled climate, compliance and participation in safety behaviours.

Adherence to the Code of Professional Conduct (ICE 2008) would ensure that engineers would be acting ethically, but as a deontological approach where they are expected to do their duty the development of ethics reasoning is not a specific requirement of the professional engineer, and without this the engineer is relegated to the role of technician. Many professional institutions have developed codes similar to the ICE Code.

## Ethics Reasoning

Engineers are schooled at the highest levels in the technical aspects associated with construction and are well versed in the need to ensure structural integrity because of the high value placed on human life. None-the-less Rahman et al (2007) found that the construction industry is a perfect environment for ethical dilemmas with its low-price mentality, fierce competition and paper-thin margins. This situation is all the more acute 3 years into a global recession that commenced with the collapse of the property market and banking failures, leading to the failures within the construction industry in a number of major countries.

In recognising that profitability is a motivation for effectiveness Orr (2007) maintains that "*the desire for profit should not come before an engineer's duties and responsibilities*" and this is the very area where ethical dilemmas can be most acute. When social conditions are bad "*people adapt to them by lowering their intellectual and moral capacities but in doing so they are acting contrary to their nature which in turn leads to mental and emotional disturbances*" (Fromm 1947). Cathy Kopp, Executive Director at ACCOR addressing a health seminar in Korea highlighted the fact that although people are working less today than in the 1950s they are under greater demands and experience higher levels of stress, (McAleenan 2008). The objective conditions since 2008 are more severe and the demands put on workers and professionals are greater again. Fromm (1947) concluded that "*because man cannot change his nature, he resolves the contradictions by changing the circumstances in which he finds himself*".

When we approach the questions of prevention through design from an ethical standpoint it is necessary to understand something of what drives ethical behaviour and that arise from whichever standpoint we choose. From the founders to the current leaders of the profession the need for engineers to behave ethically has been a central tenet of what they do and what they believe should be the situation for their professions. The Washington, Dublin and Sydney Accords all stress the requirement for engineers and graduates to demonstrate ethical responsibility to public safety and to consider the impact of their activities on economic, social, cultural, environmental and sustainability requirements of society (IEA 2009).

The professions have encapsulated the requirement to behave ethically in their Codes of Professional Ethics. Engineering standards have been developed and published and are the required means of designing and constructing structures. Universal principles on integrity (OECD 2004a) have been applied and implemented in national codes (e.g. FRC 2010) and laws, (e.g. Sarbanes Oxley Act 2002) that corporations must follow, and health, safety and environmental duties are imposed by statute. For instance, in Malaysia the construction industry has introduced codes of ethics for contractors and the government requires stakeholders to enforce existing codes to protect the good name of engineering (Rahman et al. 2007)

The need for ethics in engineering has resolved itself generally as a deontological ethic with it being a duty to behave ethically and the 'how to behave' being codified. Notwithstanding the issues with deontology, problems arise not least because the rules are general in nature and are insufficiently defined to cover every situation, but also because the rules may constrain the scope for exercising professional judgement. Warnick (2010) has identified a number of other issues with ethics; respondents stated, amongst other things, that they wish they could have left college knowing "definitions of right and wrong and what is acceptable", what are "international work ethics", that "values are not absolute" and the differences in culture and how cultures should relate to each other.

Kohlberg advancing the work of Piaget on the development of moral reasoning (cited in Crain 1985) has identified six stages of moral development. Stages 1 and 2, defined as pre-conventional, are applicable to children up to early teens. Stages 3 and 4, called conventional morality because they are the levels of the values, norms and expectations of most members of conventional society. Stage 3 moral or ethics reasoning is fundamentally concerned with the individual's perceptions of good and works well in close interpersonal relationships as between family and friends where people are expected to live up to the expectations others have of them and behave in good ways. Stage 4 is concerned with and is shaped by the need to maintain some kind of order and functionality in wider society. There is a greater emphasis on obeying the laws of society and respecting authority in order to avoid conflict and societal breakdown. There is a sense in which Stage 4 requires less moral reasoning to obey the rules than Stage 3 where the individual must determine what is good for others in his relationships. Rather than reversing the stages they could be viewed as co-equal. Kohlberg (cited in Crain 1985) answers this criticism by stating that subsequent stages do not negate prior stages but assimilate and take the learning to the higher level. Thus Stage 4 reasoning enhances stage 3 reasoning.

Post-conventional morality has two further stages. Stage 5 is concerned with how society could and should be, particularly when one considers that a well ordered and functioning society is not necessarily a good one. In this stage of moral development the moral agent considers in a Kantian way society in the abstract and what is good for it and what rights and freedoms its members should have.

Those who are reasoning at Stage 6 are considering the universality of ethical principles; what is good for one is good for all, indeed Fromm (1947) states that in order to know what is good for the self one must know what is good for humanity. For him the most general principles "*follow* [of necessity] *from the nature of life in general and of human existence in particular, and the first 'duty' of all life is to affirm and preserve its own existence*". In this respect ethical behaviour is on the basis of what is just rather than what the law required. However a difficulty Kohlberg discovered was that his subjects were not reasoning consistently at this level and he was finding it difficult to score them higher than Stage 5.

Kohlberg (cited in Crain 1985) distinguished Stages 5 and 6 as post-conventional because most young people arrive at Stage 4 some-time in their 20s but few develop or retain as a matter of course Stage 5 reasoning, thus it is, he argues, beyond the conventional mode of thinking of most people.

## The educational deficit

What stands out in respect of professional ethics is the requirement to behave ethically supported by codes and regulations that direct professionals in the 'right direction'. Ethics thinking is not prevented but is constrained by the contradiction between a rules based approach, a society of laws and the requirement to act above and beyond any duty owed to employers and clients and put the public interest first.

College and university programmes do not omit ethical issues but when they arise the issues are often addressed through the provision of answers (or the gleaning of such from the students) more than the exploration of and deeper reasoning about them. Kohlberg's finding that Stage 5 reasoning rarely appears before the mid-20s and never becomes very prevalent (Crain 1985) means that normally students graduate before arriving at this level of reasoning and if they later arrive at this stage it is unlikely to become their prevalent mode of reasoning. Thus professional engineers may be facing their professional reviews with no more than a deontological, Kantian-like ethic. In other words if a professional is one whose duty is to the greater good of the public at large in all aspects, economic, safety, environmental, cultural and so on, he or she finds themselves limited to reasoning within the bounds of established conventional laws and rules about what is good for society rather than applying their own reasoning to what should be.

There are exceptions to this as is to be expected from any general assertion, but the exceptions are not found in the engineering projects that claim headlines with their creativity and ingenuity of design. Such projects emerge from the mathematical, scientific and engineering learning and competence of the professional.

The immediate benefits of any project may obscure the long-term or even distant negative effects. Out of town shopping malls for instance bring reduced prices and convenience to customers but bring about the loss of town centre businesses and the sense of community engendered by vibrant town centres. In other cases, such as the spectacular creations in the Gulf state, the poor labour conditions on some projects with tens of thousands of migrant workers housed in over-occupied, amenities-poor accommodation and subjected to unsafe working conditions were overshadowed by the spectacle of the finished works (HRW 2009, and Hari 2009).

It would be wrong to suggest that it is all negative. The Aga Khan Award for Architecture demonstrate that substantial projects can be undertaken and be successfully completed where the primary objectives are social and aimed at the advancement in human needs in all the areas outline by the Washington, Dublin and Sydney Accords, (AKDN 2011).

## Developing Ethics Reasoning in Design Education

Kohlberg's work has demonstrated that progress from one stage to the next is an invariant sequence; learners will always pass from one stage to the next in sequence, however this assertion is worth challenging. Though most people will arrive at and remain at Stage 4 sometime in their mid-20s, the method by which they can move to the next stage is open to to appropriate formal educational input. Blatt and Kohlberg (cited in Crain 1985) presented moral dilemmas to children and encouraged active group discussion including the presentation of arguments one stage above where most were at. This method was designed to induce cognitive conflict wherein the views of the learner becomes confused by information that was at odds with his view and consequently his means of resolution of the conflict is via the adoption of an advanced and more comprehensive position.

Under controlled circumstances half of the participants moved up one stage over a 12 week period of weekly discussions. Replication however did not produce the same level of results, but over a longer period one third of students moved up a stage. The general trend displayed is that discussion of ethical dilemmas, over several months, produces significant upward changes in moral reasoning in participants.

Ethics reasoning and the facilitation of its development is not about producing specific moral behaviours. It is concerned with the reasoning process and the output of a programme is graduates whose ethics development and subsequent ethical behaviour is a result of their own thinking and not imposed by rules or authority.

The exercises designed to facilitate ethics reasoning must be based on matters of social and individual good. Fromm (1947) describes technical competence in particular professions such as engineering as emerging from the sciences, in particular mathematics and physics. Without a foundation in these sciences, engineering competence is unlikely to occur. In respect of ethics he contends that an individual's ethics are based on what is good for him qualified by "*what is good for him is necessarily good for man in general*", and this is at the core of professional ethics. In order to know what is good for others, what is good for humanity there must be a foundation of knowledge and understanding about humanity, i.e. there is a need to know what it means to be human. This Fromm (1947) calls the 'science of humanity'.

Some work in this area has indirectly taken place in Limerick University (Philips 2008) and Ulster University (McAleenan C 2010). Phillips' engineering students were provided with case studies in which they were required to develop explanations and alternative solutions taking account of legal and philosophical matters, including lectures from those faculties. McAleenan tasked students with the development of disaster prevention and recovery solutions based on the lessons from the New Orleans Katrina disaster. Students were required to consider the social, cultural, religious and legal impact of their technical solutions and received appropriate supporting lectures from a range of disciplines.

## Conclusion

Hann (1968) (cited in Crain 1985) found that students in Berkeley involved in the Free Speech Movement demonstrated very strongly post-conventional thinking where-as students not so involved did not demonstrate this level of thinking. Kohlberg has demonstrated that his methods for enhancing ethics reasoning are effective. To meet the ethical requirements that professionals need in order to assess the impact of their work on construction workers, end users and the general public now and into the future it will be necessary to introduce and integrate a short programme of ethics reasoning into the first and final years of undergraduate programmes with the objective of raising students level to Kohlberg's Stage 4 in the first year and to Stage 5 in their final year. The former to bring forward the age by which most young people generally arrive at Stage 4 and the latter to bring them to Stage 5 which is critical to objective professional reasoning.

The use of this method at undergraduate level in order to achieve a successful development of ethics reasoning at an earlier age can be effectively tested by the universities and the professional institutions when candidates come for their chartered/professional review. With this intervention the professions (and this is true for all construction professions) will develop the ethics reasoning capabilities of their cohort up to a level that is expected of true professionals.

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# The Degree of Sophistication of Ethics Reasoning Amongst First Year Under-graduate Students

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## Abstract

Safety decisions and decision-making in construction emerge from the ethical positions and the capacity of the decision-maker. Professions have codes of ethics to guide members' behaviour and decision-making while Universities may provide programmes that include an ethic dimension involving courses in moral theory or introductions to professional codes. Evidence suggests that the focus of engineering ethics programmes tend towards individual or micro-ethics, rather than macro or social-ethics concerned with collective social responsibility. Few universities require ethics related programmes and where they are required students tend not to consider them mainstream. In 2011 a short programme initiated in University of Ulster tested the level of ethics reasoning among first-year students against Kolhberg's levels of moral development to determine whether such a programme could achieve an increase in sophistication, and establish the degree to which that could be achieved. Initial findings confirmed most students approach ethical dilemmas in a conventional manner and some forthrightly rationalised unethical practices on the basis that such practices achieve success. This paper examines work with the group and describes how the research paves the way for a detailed examination of how ethics reasoning can become an integral aspect of the construction safety curriculum.

*Keywords*

Moral development, Kohlberg, university ethics programmes.

## INTRODUCTION

Safety decisions and decision-making in construction emerge from the ethical positions and the capacity of the decision-maker. Professions have codes of ethics to guide members' behaviour and decision-making and University programmes include an ethic dimension involving courses in moral theory or introductions to professional codes. Evidence suggests that the focus of engineering ethics programmes tend towards individual or micro-ethics, rather than macro or social-ethics concerned with collective social responsibility (Herbert, 2000, 2002). Current thinking tends toward a brand of professional ethics that demands ethical behaviours that are supported by codes and regulations, which posit 'the right direction'. McAleenan and McAleenan (2011) suggest that while this confines ethics thinking it does not necessarily prevent it. Rather ethics thinking is "...constrained by the contradiction between a rules based approach, a society of laws and the requirement to act above and beyond any duty owed..." Fromm (1947), in discussing ethics, contends that an individual's ethics are based on what is good for him, qualified by "what is good for him is necessarily good for man in general", and this is at the core of professional ethics. In many ways this is an approach to defining professional ethics that is largely sidestepped in education and professional life. Davison and Kock

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(2004) describe it as concerning one's behaviour and practice in professional life and point towards codes of conduct to guide the necessary decision-making. Hamzah *et al.* (2007) refers to professional ethics as "a system of norms to deal with both the morality and behaviour of professionals in their day-to-day practice". Vee and Skitmore (2002), citing Harris *et al.* (1995) and Calhoun and Wolitzer (2001) indicated that professionals gain integrity and respectability to some extent through professional bodies whose mission includes that of reflecting its members' "...ideals for education, standards and ethics...". They continue "These are embodied in codes of practice, which define the responsibilities of professionals and are the cornerstone of any ethics programme."

Rather than being constrained by the rules embodied in the myriad professional codes of ethics the professional needs to have an understanding of and an ability to reason out the ethical issues within any given scenario, including the difficult public policy issues, (Guenther, 2011). Indeed the ironic aspect of professional codes of ethics is that to abide by them the professional needs to be able to question them, to bring them alive (Strahlendorf, 2005) and to rationally reason that they are the appropriate ethical approach to professional practice. Chang and Wang (2011), citing Reddy (2008) concur, suggesting that the field of ethics is considerably broader than a simple analysis of right and wrong. It focuses on 'right conduct' and the 'good life', the life worth living or life that is personally satisfying. In that regard there rests a need to go beyond the teaching of ethical codes to the teaching of ethics reasoning.

In keeping with the ethics reasoning approach to education Phillips (2008) indicated that the challenge in all of this is to evoke consideration for the ethical issues encountered in the engineering profession and to provide a safe forum for discussing the implications for the practice of engineering. Winston and Bahnaman (2008) discussed the need for professional education to provide academic preparation in both theory and practice, citing Delaney 2007 who had highlighted the fact that, traditional professional education has placed the emphasis on theory because of the need "to prepare professionals who can integrate theory into their practice". McAleenan and McAleenan (2011) concluded that;

> "To meet the ethical requirements that professionals need in order to assess the impact of their work on construction workers, end users and the general public now and into the future it will be necessary to introduce and integrate a short programme of ethics reasoning into the first and final years of undergraduate programmes".

## KOHLBERG'S LEVELS OF MORAL DEVELOPMENT

Kohlberg's work with young people identified three stages of moral development centred on conventional morality, or that morality to which most people in society adhere to, these he termed pre-conventional, conventional and post-conventional. Within each of these stages he discerned two levels of development, which were found to develop in invariant sequence and to correspond to broad age categories. Thus pre-conventional morality developed and was found to be the primary way of reasoning for young people up to their early teens. Conventional morality develops in the teenage years and persists through to middle age (hence conventional) for most people. Post-conventional reasoning, which Kohlberg found not to develop, or where it does not to become the dominant mode of reasoning in most people, generally does not develop until middle age. The stages and the key indicators are summarised in Table 1.

Table 1: Kohlberg's Stages of Moral Development

| Kohlberg's Stages | | Indicators |
|---|---|---|
| Pre-conventional Stages | | Focus on the self. Up to 10-13 years. Behaviour motivated by anticipation of reward and penalty |
| 1 | Punishment and obedience | Avoids punishment.<br>Defers to power/authority |
| 2 | Instrumental Exchange | Marketplace exchange of favours/ blows.<br>Do what is necessary to satisfy own needs. |
| Conventional Stages | | Focus on significant others.<br>Early-teens to middle-age (most people end up here)<br>Conformity to the rules of ones own group |
| 3 | Interpersonal (tribal) Conformity | Conformity to stereotypical behaviour, values and expectations of society or peer group.<br>Does what is socially acceptable. |
| 4 | Law and Order (societal conformity) | Respect for fixed rules, laws and properly constituted authority.<br>Defends given social order for its own sake.<br>Responsibility to welfare of others. |
| Post-conventional Stages | | Focus on justice, dignity for all life, Common Good.<br>Few reach this stage, most not prior to middle age. |
| 5 | Prior Rights and Social Contract | Logical application of universal abstract moral principals. Individual have natural rights and liberties that are prior to society and which society must protect. Justice is proportionate to the circumstances and the need. |
| 6 | Universal Ethical Principals | Acts out of universal principals based on the equality and worth of all living things. Persons are ends in themselves and that the dignity of another person is equal to one's own in all situations.<br>Rights have precedence over liberties.<br>Rare for anyone to reach this stage. |

Though invariant in the sequence of development, once a level is arrived at the earlier modes of reasoning are not discarded but rather are assimilated into the overall reasoning by individuals but with higher levels tending to dominance, thus you would generally expect someone to reason that following the laws of society is for the good of society rather than because they fear the punishments that may accompany a breach of those laws.

Though disputed in terms of the timescale and success in progressing to higher levels, Kohlberg suggests that individuals are capable of achieving a single higher level within a short period of intense critical analysis of ethical dilemmas. The process involves setting a series of dilemmas and the individuals in a group exploring how they should and shouldn't respond, and examining their reasoning as part of the discussion. Kohlberg has suggested that in a 12-week period of structured discussion a significant number of the participants will achieve a higher level of reasoning.

## RATIONALE

By the time young people arrive at college/university there is the reasonable expectation that they will have reached a level of moral reasoning that is firmly within the parameters of conventionality, certainly that they will have clearly identified with their family, peer groups or community, have a sense of loyalty towards them and at least make moral judgements that are acceptable within those groups. There is also the expectation that, separate from these peer groups that they will consider the wider societal implications of their decisions and reason accordingly.

Orr's (2007) presidential address to the Institution of Civil Engineers (ICE) concluded that professional integrity was wider than technical competence and the recognition of personal limitations but also included a responsibility to act in the public interest at all times especially regarding structural safety, sustainability, climate change and the global implications of local actions. Ethical reasoning associated with this degree of integrity is substantially more than defending social order for its own sake. It looks to the universal principals of justice and welfare of mankind now and into the future. The requirement is that professionals are by definition expected to exercise their moral judgement at a post conventional level. If we accept Kohlberg's stages of development and when people reach the different levels, then in general, without interventions, young professionals are going to graduate with at best a conventional level 4 moral reasoning, a stage far short of what is required of them as a professional. Warwick (2010) identified a number of issues amongst recent graduates working internationally which illustrated that some were dissatisfied even with the sufficiency of ethics rules they had been taught, an indicator that they were very much reasoning at Kohlberg's level 4.

Given the above, it was concluded that undergraduate students progressing through university would benefit from a specific structured intervention designed to raise their level of ethics reasoning from 3 or 4 to 5. Accepting Kohlberg's educational process with the caveat that the timescale and success rate may be subject to modification on experience, a short programme was designed to test the proposition that a change in ethics reasoning amongst Quantity Surveying students could be achieved.

There was no space in the curriculum to facilitate this project in depth, but agreement was reached to borrow time from an existing programme where an ethics element was not in conflict with the module objectives; Construction Business Management, an area identified by Hamzah *et al.* (2007) as a perfect environment for ethical dilemmas. The target group of first year students, 40 in total, was selected for participation to determine;

- A base line, i.e. was their initial level of ethics reasoning in accord with Kohlberg's model, and whether
- Any change in their ethics reasoning could be observed after a short introduction to ethics and an opportunity to explore a number of ethical dilemmas.

The model adopted for the delivery of the programme was a modification of Eckensberger's model of moral judgement, which took account of Kohlberg's stages of development rather than Eckensberger's framework for moral judgement, Figure 1.

## RESEARCH OBJECTIVES

This study was undertaken to explore the level of ethics reasoning among first-year students against Kolhberg's levels of moral development to;

- Determine whether such a programme could achieve an increase in sophistication, and
- Establish the degree to which that could be achieved.

## RESEARCH METHODOLOGY

The first year students on the BSc in Quantity Surveying with Commercial Management programme were selected as they were fresh onto the programme and their developmental progress through Kohlberg's stages could be tracked as they move through 3 years of academic study and one year of industry placement to final graduation.

The degree programme has recently been revalidated so any major shift or addition to the modules without justification was not an option. Accordingly there was some limitations on the amount of time that could be made available, which affected the selection of the programme content, the delivery method and the method of observation. The programme was delivered as follows;

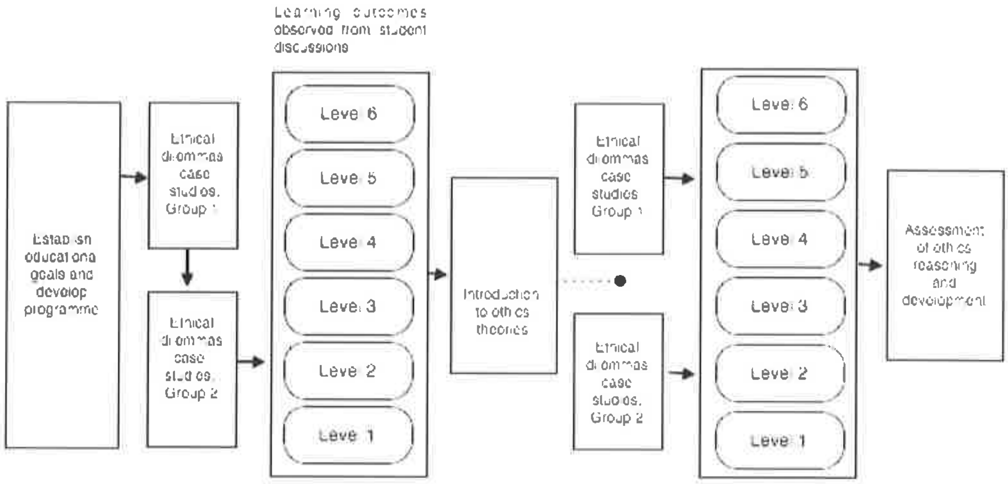

Figure 1. Study Framework

Week 1 - Students were introduced to a number of increasingly more complex ethical dilemmas in which they were asked;

- How would you address the matter?
- What were your reasons for taking a particular stance?

Through a series of 'What if' questions the students' responses were scrutinised and their original responses challenged.

The week 1 session is used to give a baseline for the Groups level of ethics reasoning.

Week 2 - Students were introduced to the values, which guide the construction professionals and how they are reflected in professional codes of practice and conduct. Through an exploration of virtue, deontological and utilitarian ethics the session deconstructed the codes and gave the student the opportunity to see the restrictive and potentially incorrect nature of a codified approach to conduct where ethics reasoning is not a part of the professionals psyche.

In semester 2 without introducing the class as an ethics class the students were presented with a number of scenarios, related to the particular module topic; renewable energy sources. Again they were challenged to discuss and present their reasoning behind the values and beliefs associated with technological decisions, in local and global contexts.

An observer recorded the responses from each of the sessions. Immediate response feedback sheets were collected and a follow-up survey was carried out asking a number of key questions and the data was checked against Kohlberg's levels of moral development.

## DATA ANALYSIS AND DISCUSSION

Four ethical dilemmas were presented to the students around health and safety, procurement and minor car accidents.

A number of statements centred on carrying out an act known to be unethical or illegal based on being able to get away with it, or that was considered to be common practice, especially when there was a substantial gain. The statements changed when the likelihood of penalty was increased. The rationales were akin to Kohlberg's pre and early conventional stages.

There were a number of statements about reporting the matter, especially when the consequences were particularly undesirable, illustrating an ambivalence about what they should do but deferring to authority to avoid making the decision themselves. Further ambivalence emerged when one beneficial action was justified by reference to it helping the client but another beneficial action when the scenario was reversed was taken though it deprived the client.

Generally the dominant levels of ethics reasoning that emerged were 2 and 3 on Kohlberg's scale.

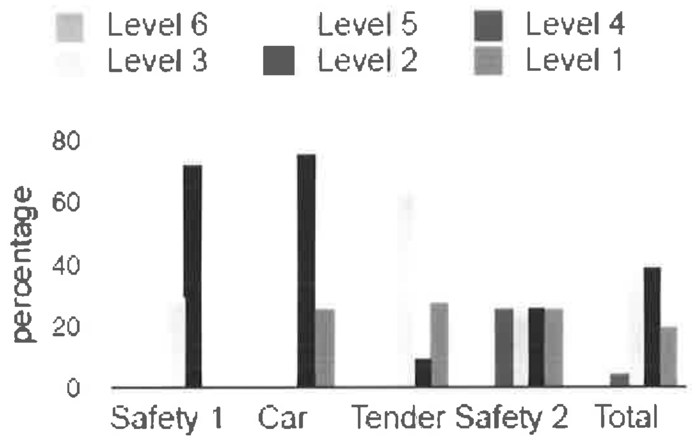


Figure 2. Analysis of Statements on Ethical Dilemmas

A significant number (50 percent) left the first seminar early for sports activities and attendance at the second seminar was down to 25 percent. They were asked to explain this in the feedback, which elicited a 50 percent response. Football matches, prior appointments, unavoidable circumstances and family commitments were the main reasons, with two stating illness, another had a job.

The group was then asked to state the key learning achieved as a result of attending the seminars. Their answers suggested that they were aware of the complexities of ethics reasoning and its applicability to real world situations but their statements on the various scenarios would suggest that their reasoning skills are at a low level. Intellectually they would appear to be ready and it may be a question of providing structured opportunities to develop and practice the skills.

The final question sought their views on what further learning they would like. There were 15 no or vague responses, 4 who wanted more rules to follow and 1 who wanted more opportunities to explore and practice the skills.

Their response followed closely the levels of ethics reasoning observed in the classroom with slightly more evidence of level 4 reasoning.

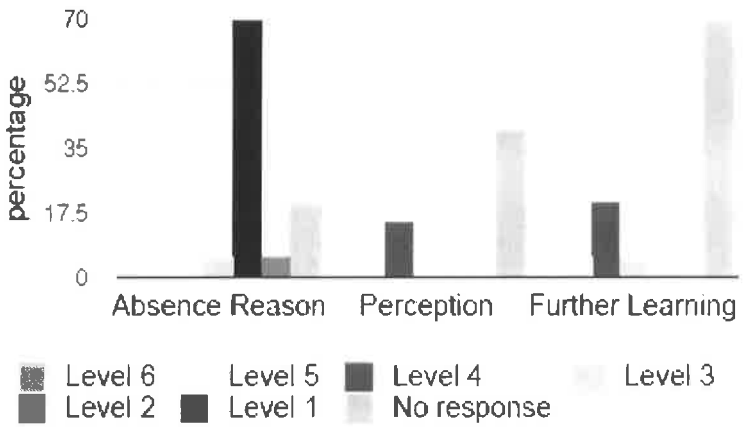


Figure 3: Analysis of responses to questionnaire following seminar 2 (20 responses)

5 months later a further seminar was conducted at which the group was asked to study the Sustainable Human Development Report (SHD Report) in advance. Attendance at the seminar was extremely low (5/6 students with some of those leaving before the end of the seminar) none of whom had read the report or prepared for the seminar. It meant that no-one could make any meaningful contribution to the discussion and nothing could be determined on the ethics issues which were a component of the assignment.

A tutorial question put to the group was: "What are the ethical issues surrounding the Government's zero carbon agenda?"

Discussion of the Zero Carbon Agenda and Carbon Trading elicited statements and expressions of unfairness regarding exploitation of people in underdeveloped and developing countries. However a strong "not in my back yard" opinion emerged despite a general agreement that alternative technologies should be developed.

Generally, the few who attended this seminar made a range of statements that varied evenly across the lower levels of ethics reasoning and displayed a sense of confused thinking.

Evidence of Kohlberg's stages of moral development were assessed but the findings did not accord with his projections that students entering university level education could reasonably be expected to have attained and be exercising conventional reasoning. It was found was that the levels of reasoning fluctuated between pre-conventional and early conventional, between levels 2 and 3. The expectation was that students would be exercising between 3 and 4.

This suggests that the assessment method was the wrong one and that the informality of discussion groups did not permit an accurate assessment. On considering the efficacy of the discussion group the students willingness to participate is a key consideration. Though discussion during the first seminar was lively, the fact that many left halfway through set the tone, namely that it was not considered a valuable academic exercise that warranted their time. The extremely low attendance at subsequent seminars would suggest that this is a relevant consideration. Another consideration may be the maturity of the students. Early in semester 1 they maybe considered as still be acting on a school ethos where an authoritarian discipline would have been the norm, but several were mature students, some coming from a work background and their non-attendance at subsequent seminars would suggest that they didn't accord the programme any priority in their course.

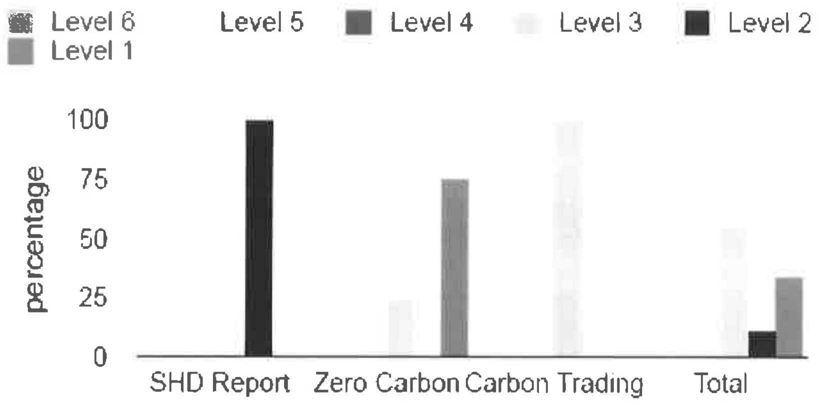


Figure 4: Discussion of Sustainability Topics where ethics reasoning is expected within the course elements

By semester 2 it was reasonable to expect a higher degree of maturity with regard to study and preparation for tutorials, but the fact that so few attended and those who attended admitted to having done no preparations meant that their ability to participate in discussion was extremely limited and it was noted that most of the few allowed one fellow student to dominate; he being more mature in years and experience at university and willing to discuss the issues.

The programme limitations and the low level of engagement by the participants meant that the there was little evidence available to make a determination on whether there was a change in the level of ethics reasoning. The expectation, (continuous line in Figure 5) was that students would enter at a minimum level 3 reasoning and through structured discourse would be comfortable reasoning at level 4 by the time they went on placement in third year. The findings suggest (dashed line) that even if the students were entering college at a lower level than suggested by Kohlberg, it would still be possible to provide a structured programme that would achieve the objectives.

## CONCLUSION

Reasoning amongst first year students fluctuated between pre and early conventional; lower than expected and indicative of a degree of unsophistication incompatible with future professional requirements. Cognisant of the weakness in the study to date the authors nevertheless hold that some form of ethics reasoning programme is necessary at professional level education, though the degree and type of programme remains to be concluded. To offset the limitations in the early work, the project will continue in an enhanced form in the 2012/ 2013 academic year with new students being provided with a more substantial programme throughout semester 1 and those who were on the 2011/2012 programme having further opportunity to participate in the enhanced programme in preparation for their industrial placement year.

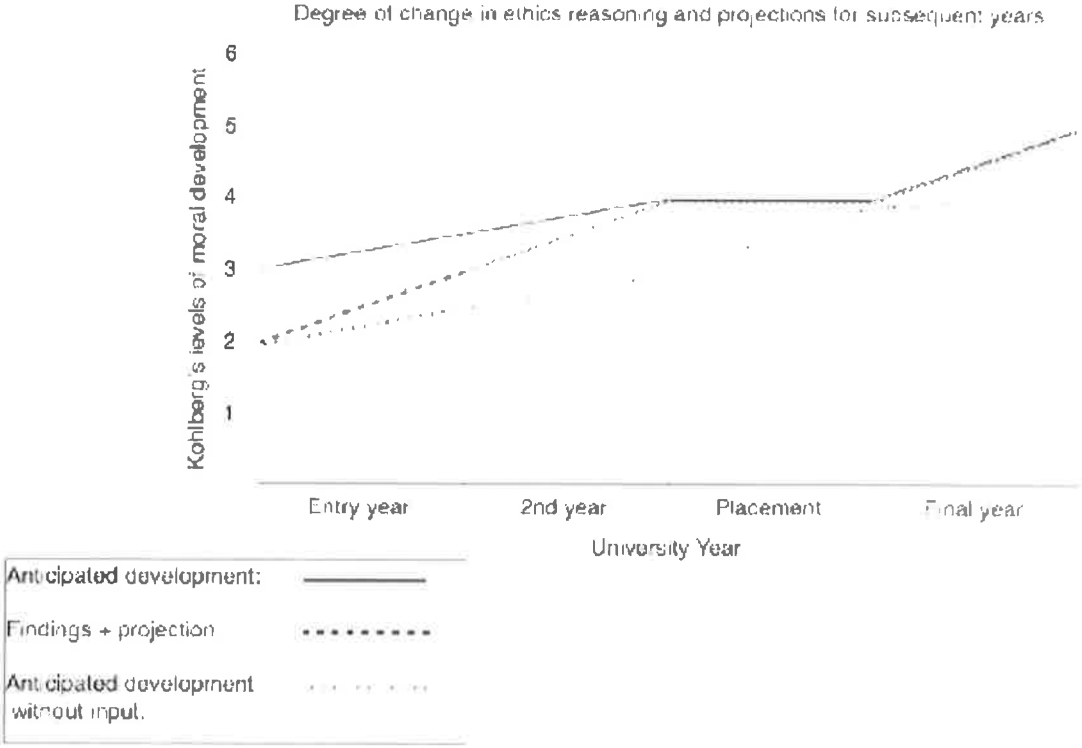


Figure 5: Projected development of ethics reasoning with and without a structured programme

The enhanced programme will be integrated into existing courses with ethical issues highlighted and students being expected to address them as a core requirement. Formative assessment of the level of reasoning will continue to be by way of analysis of their discussions with the inclusion of summative assessment of reasoning when it is deemed necessary in formal assignments. Final year students' levels of ethics reasoning will continue to be assessed through their civil engineering technology project, with the expectation that the professional practice experience gained through their placement year will be reflected in their reasoning.

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# CIB 2013 World Congress

# Maturing workplace culture in the context of evolved ethical agency


## Abstract

Culture is a concept and a descriptor of concrete examples of cultures within which man stands as the embodiment and the maker of culture and morality. This presupposes he is a self-reflective agency capable of decision-making and with the capacity to act independently. Geertz described culture as a system of uniquely human controls, a consequence of which is that morality or ethics reasoning is fundamental to culture. Kohlberg outlines an invariant progress towards ethics reasoning in a universal context, passing though the early stages of reasoning; self-interest, group interests and rule-following. These earlier stages negate autonomous action in favour of heteronomy, a rationale based on internal and external constraints.

Workplace cultures are necessarily dynamic, comprising multiple agents continuously entering and departing the matrix. The safety aspect, often defined as "the way we do things", is substantially more and deeper than a simple behaviour pattern. It is the outworking of reasoning at all levels and the perception of agency by stakeholders. Culture and ethics are identical in this model and in identifying cultural maturity the authors found that maturity is evolved cultural/ethical agency, simultaneously transpersonal and interpersonal.

The authors' ethics reasoning research with undergraduates found the level of reasoning necessary for independent decision-making lower than expected and that students' actions were guided by heteronomous reasoning that is at best morally ambiguous and at worst capable of lending itself to workplace practices that sacrifice safety for profit. Expanding the work of Kohlberg and Eckensberger this paper develops the ethics reasoning research, linking it to culture and the maturity levels of individuals and organisations. Formal intervention to develop the cultural and ethical maturity of early stage professionals will contribute to their future ability to positively effect the evolution of ethical agency in their occupations.



**Keywords: Workplace Culture, Ethics Reasoning, Maturity.**

## 1.Introduction

Globally the construction industry has a reputation that generally falls well below what can reasonably be called ethical, being as it is an environment where competition between contractors leads to a low price mentalities, fierce competition and paper-thin margins and thus to quality and safety reductions to cut costs and save time, (Hamzah Abdul-Rahman et al. 2007, 2010). Hamzah et al (2007, 2010) summarised research in Australia and South Africa that identified several unethical conducts and ethical dilemmas in the construction industry such as; corruption, negligence, bribery, conflict of interest, bid cutting, under bidding, collusive tendering, cover pricing, frontloading, bid shopping, withdrawal of tender, and payment game. In 2003 the Cole Royal Commission (cited in McCarthy 2012) reported on a general disregard for the law in the construction and building industry and the Building Industry Task Force in 2005 and 2006 reported that the "industry remains plagued by a culture of civil disobedience, coercion, intimidation, threatening behaviour, and the contempt for the law". Construction Forestry Mining and Energy Union (CFMEU), however refuted the Cole Commission process as being contrary to natural justice and the particular assertions of 'thuggery',on the part of workers in the industry (Roberts 2003).

Some four years into the global recession in which construction has suffered badly as a result of the cancellation or suspension of major infrastructure projects, negative equity housing and the banks calling in of loans from small contractors, competition and reduced margins remain a central feature of a landscape in which the International Labour Organisation (ILO) World Congress on Occupational Safety and Health [Seoul 2008] predicted that such a climate would have a direct negative impact on the safety and welfare of workers as employers sought to minimise losses to the bottom line (McAleenan and McAleenan, 2010). It is this latter aspect of the industry's culture, it's "safety culture" where workers face the risk of harm, that had become the focus of attention of those working in the field of occupational safety and health. A range of approaches have being adopted to manipulate that culture to achieve improved outputs in safety compliance, reduced accidents and a positive safety leadership from senior management and board teams. However the issue is problematic, not least because there is no universally accepted definition regarding what constitutes a "safety culture", much less what it should look like.

The authors' ethics reasoning research with undergraduates on the BSc Quantity Surveying programme found the level of reasoning necessary for independent decision-making lower than expected and that students' actions were guided by heteronomous reasoning that is at best morally ambiguous and at worst capable of lending itself to workplace practices that sacrifice safety for profit. Expanding the work of Kohlberg and Eckensberger this paper develops the ethics reasoning research, linking it to culture and the maturity levels of individuals and organisations. Formal intervention to develop the cultural and ethical maturity of early stage professionals will contribute to their future ability to positively effect the evolution of ethical agency in their occupations.

## 2.Culture

A common phrase used to explain safety culture is "it is the way we do things here"; but this is simplistically inadequate in that it describes no more than the subjective actions of workers in the workplace without consideration of the contexts in which that work occurs and the motivations of the workers to perform in that manner. It is fundamentally a behaviourist approach without an appreciation of the character of the individual workers, their system of motivations which underlies but is not identical with their behaviour, (Freud cited in Fromm 1947). Thus to an observer looking at a site where work is apparently being carried out in compliance with safety procedures, he cannot, without deeper analysis, determine whether he is observing a "safety culture" or merely a momentary culture of work being done safely, of safety being an incidental output of other motivations. Geertz (1973) refers to this basic statement of what is happening as a Thin description of culture. Culture is not just about behaviours, though conscious behaviours are a cultural phenomena. Freire (1973) has described culture as man's transformation of nature by his work. This transformation is the outworking of a conscious relationship with the world in which man "organises himself, chooses the best response, tests himself, acts and changes himself in the act of responding". He is both in the world and of the world. In this there is a dialectical relationship in which man is both the embodiment of culture and the maker of culture, a duality that negates definitions of culture as abstract matrices in which man merely moves.

Geertz (1973) described culture as a system of uniquely human controls. A consequence of this is that morality, which embodies controls, and ethics reasoning, which informs a rational understanding of what man should or should not do, are fundamental to culture and, following Freire (1973), this presupposes that man is a self-reflective agency capable of decision-making and with the capacity to act independently. Geertz's (1973) thick description of culture is that there is a duality between the manifestations of culture, which he describes as signs and symbols to which meaning must be assigned, and man's interpretation and application of meaning to those symbols. This leads to a position whereby culture is not only uniquely human, but is unique to each human in that each person experiences and interprets culture for himself. What appears to the casual observer to be a shared culture, whether at the level of society or of sub-groups such as workplaces, is in fact a synthesis of multiple manifestations of culture that, below the level of the observed, is a permanent dynamic that objectively gives meaning to the observed phenomena.

This observed workplace culture is itself also necessarily dynamic, comprising multiple agents continuously entering and departing the matrix, each bringing new interpretations, abstracting from and assigning different meanings to the environment in which they are working. Thus contrary to the idea that culture is shared it is more appropriate to consider culture as being experienced and evolving in a shared place that leads to similar but non-identical responses to the phenomena of work.

## 3.Moral and ethics reasoning

Culture and morality are inseparable (Lemburger 2011) and man as a moral agent is by definition self-reflective and autonomous (Körner 1995, citing Kant). The function of morality/ ethics is that it is concerned with guiding behaviour such that at a fundamental level that behaviour is non-injurious to others and in its more evolved forms it actively contributes to the good of others (Fromm 1947). This distinction illustrates a differentiation between a morality that is mandatory, "you must not harm others", and thus an absolute negation of autonomous agency, and one that is desirable but ultimately non-obligatory, "you should do good", a partial recognition but not full acceptance of autonomy. Reconciling this apparent contradiction is a necessary prerequisite to holding that each is accountable for their actions (Eckensberger 2007). Hegel (cited in Engels 1894) held that freedom of the will is the appreciation of necessity; that is the capacity to make decisions with the knowledge of the subject . For Engels (1984) this consisted in man's control over himself and of external nature, a control founded on natural necessity and emerges as a result of historical development. Jean Piaget and later Lawrence Kohlberg (Partington 1997) explored the development of moral reasoning in children and young people to understand how their moral choices were arrived at. Piaget saw two distinct stages of heteronomous or constrained morality and autonomous reasoning that takes place within a social context. Kohlberg's advanced Piaget's work (Crain 1985) and his stages of development of ethics reasoning commences with pre-conventional reasoning amongst young children informed by fear of punishment then of self-interest. Conventional moral reasoning stems from tribal/ group and latterly societal conformity. Post conventional reasoning is based at the penultimate stage on the recognition of universal rights and abstract moral principals and at the ultimate level morality is based on the recognition and acceptance of equal existence of all living beings. Rules for moral behaviour are no longer necessary as the dignity of each individual is given due consideration, in all circumstances (Coverston n.d.). In this we see the transition from constrained moral choices to autonomous decision making, albeit not until the highest stage is arrived at.

Eckensberger developed Kohlberg's stages from 6 to 11 in four levels (Crain 1985). He introduced two social interpretation spheres, interpersonal defined by concrete interactions with concrete persons and transpersonal, determined by functions and roles. As a level of maturity the latter is indicative of the moral agent reasoning beyond personal considerations towards universal principals, where-as the former necessitates empathy and reciprocal respect and is akin to the ultimate stage identified by Kohlberg. Criticism of Piaget and Kohlberg's theories (Partington 1997) centre on their position that moral reasoning develops in an invariant sequence (across all cultures) and once a level of reasoning is attained is irreversible. Partington (1997) illustrates the negation of non-reversibility by reference to societies that have degenerated from more enlightened periods into fascistic and totalitarian states ultimately leading in some cases to the end of that society. He also holds that the universality of the theory is not supported when one considers other cultures where non-rational philosophies are dominant. His former point is in error in that he has conflated the coherent consciousness of the individual with the dialectical interrelationship of multiple consciousnesses that make up society. The fact that the dominant political forces in a society reason at an immature stage compared with less dominant members does not nullify the theory but in his error has exposed the dichotomy between the maturity of individuals and the maturity of the group or groups to which they belong.

## 4.Cultural maturity in organisations

McAleenan and McAleenan (2009) have been developing an analytical process for determining with a high degree of accuracy the cultural maturity of organisations. A number of core criteria are identified that are considered in their totality, the absence of one or more of which will severely impair the company's sustainability in times of economic crises and which have a negative impact on its ability to remain viable relative to competitors in times of economic stability. The criteria are Corporate Social Responsibility, Innovativeness, Resourcefulness and Autonomous Decision-making Units. Notwithstanding the OECD (2004) Principles of Corporate Governance requiring corporations to conduct their business with financial integrity and in a manner that respects their key stakeholders interests, it is an indicator of cultural and moral maturity that businesses no less than individuals act morally and from optimum levels of reasoning. The fact that some businesses do not act in this fashion is not a negation of the integrity and maturity of the many individuals that comprise that business at any given point. The dominant agents in a business are the owners and shareholders. Their experience and interpretation of cultural manifestations are as unique as those of employees but with the added qualifier that their decisions and actions carry a force that outweighs those of "subordinates". The worker is constrained by the decision making authority of the employer and those he appoints to manage on his behalf. This negates the fourth criteria, that the organisation recognises and supports the decision making capacity of autonomous agency within the workforce.

Though required to balance self-interest with social interests, it appears counterintuitive to employer and employee alike, that this should be the case in workplaces, hence the activities of workers are determined by external as well as internal constraints. It does not follow that the requirements of the employer are followed unthinkingly or in agreement, thus pronouncements to work safely are interpreted individually in the context of time pressures, perceptions of employers, budgetary constraints and a host of other cultural signs in the environment. Kohlberg's (cited in Crain 1985) and Eckensberger's (2007) stages of moral development are universal (at least within the culture where they were developed) and applicable to all individuals. By this rationale employers and their agents are capable of attaining those highest stages of universal moral principals that support the universal rights of all. However research conducted from the 1950s into the biological roots of ideology was summarised in 2003 in the paper "Political conservatism as motivated social cognition", (Psychological Bulletin vol.129, p339, cited in Graham and Estes 2012). It "*concluded that some of the defining aspects of conservative ideology - resistance to change and justification of inequality - were motivated by deep seated psychological needs to manage uncertainty and threat*". It follows that as uncertainty increases, as in the present economic conditions, so too will the resistance to change and the justification of inequality.

Though less well researched a liberal ideology is defined by such characteristics as open-mindedness, creativity and curiosity. The world is not polarised into these two ideological positions, it is much more complex with individuals holding ideological positions that are more conservative on some matters and more liberal in others, for example libertarians may tend to economic conservatism but be socially liberal. Nor is it a question of either position being necessarily false. However these ideological differences extend to moral judgements with liberals more likely to be offended by inequalities and suffering and conservatives by betrayal of in-group disrespect for authority and tradition, (Graham and Estes 2012). Businesses, particularly large corporations which are influential on smaller companies, are structured along and succeed as a result of conservative practices. The organisational structure defines the roles and responsibilities of managers, defines the relative status and norms of behaviour of staff and line functionaries, mechanisms and processes for allocation of resources and in general sets the rule for the game (Ghoshal and Bartlett 1995). Those most likely to rise in the business world are those whose world view is conservative, at least in the sphere of economics.

Conversely in times of uncertainty it is these qualities of the business and those who run them that are least suited to effecting the necessary changes that will meet the challenges they face, thus many companies have failed during times of economic crises. McAleenan and McAleenan (2010) in exploring strategies for success found that though they may be successful, to a point, they are fundamentally flawed in that when circumstances change or new conditions manifest themselves the strategies will fail. What was required was evolution on an ability to develop novel strategies, and this it appears lies with those of a liberal ideological root, that is [ordinarily] those who are not at the helm of organisations. An illustration of the point is Semco (Semler 1999), a large company facing closure during Brazil's recession in the 1980s. Semler (1999) was given the business by his father and brought to it a more liberal agenda developed in an unconventional youth. As a result of the radical ways in which he restructured the company and the autonomy he recognised and encouraged, Semco was one of the success stories of that period made possible by the innovativeness and resourcefulness of his workforce.

In parallel with the development of cultural maturity metrics (McAleenan and McAleenan 2009) research has continued into development of programmes with undergraduate built environment students aimed at developing their stages of ethical reasoning (McAleenan and McAleenan 2011, 2012). This critical aspect of their professional development/ personal maturity, in preparation for their eventual management and/ or control of companies operating in the construction field and beyond links directly to their future ability to positively effect ethical agency in the industry The success of a company, whether it is in economic terms or in meeting its social obligations to those who work for the company, is dependant upon the company achieving cultural maturity levels akin to the optimum levels of ethical reasoning developed by Kohlberg (Crain 1985) and Eckensberger (2007).

## 5.Conclusion

Culture is a poorly understood concept within the safety profession, who tend towards viewing it as a concrete object-in-itself capable of manipulation to achieve particular ends; e.g. improved performance and zero accidents. However this tendency is not an amenable conceptionalization of culture to shed meaningful insight into the ills of the construction industry (Gajendran et al 2012). Culture is the context in which man exists, no less so in the workplace than in society at large. The individual will interpret cultural manifestations, behaviours, institutions, instructions and so on, and respond in his own unique fashion, even within the constraints imposed by the circumstances. Though superficially it may appear that many are responding identically, fundamentally that is not the case.

Programmes that enhance the ethics reasoning of professionals, those who will be influential in the organisation and running of businesses are a pre-requisite to the development of ethical and cultural maturity of companies. Integral to this is the need to recognise, value and thus support the autonomy of workers and managers without which there can be no mature agency. As the research develops at student level a further phase would be to design programmes to support the transformational potential of the maturer reasoning professional on their professions, their companies and the industry in which they work.

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# Public and Workplace Safety and Health in Hydraulic Fracturing

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## Abstract

Fracking, a universally recognised term, which refers to hydraulic fracturing of gas bearing rock layers allowing their gas to be released into specially constructed collection wells. Practiced in North America, Europe and Asia the growth of this industry brings environmental and public health concerns to the fore. In April 2012 the UK's Department for Energy and Climate Change released an independent report, focused solely on potential seismological activity, which recommends stricter controls and procedures for developers extracting shale gas in the UK. Also in 2012 a North Carolina conference convened with the following objective; "to facilitate informed discussion to ensure that science-based policy decisions are made on energy development that will best serve the citizens ...". A symposium on emerging hazards, at the EU OSH Strategy conference 2012, discussed how existing hazards were reemerging in new industries, particularly the fracking industry. While much has been written and spoken about the scientific and technical aspects of fracking, issues such as public and workplace safety and health need to be thoroughly addressed if the debate and ultimately final choices are to be appropriately informed.

The researchers preliminary scoping found concerns about; increased salinity of water supply adjacent to fracking sites, respirable crystalline silica dust in sand extraction sites, air and water quality, toxicity of drilling fluids and hazardous wastes. In this paper the authors adopt a multi-disciplinary approach involving value engineering, sustainability and ethics; exploring how functional aspects of engineering's societal responsibility; delivering sustainable development through knowledge, skills and professional expertise, are being addressed. In particular it;

- Provides a synopsis of the current 'fracking-related' public and workplace safety and health research, and
- Discusses safeguards drilling companies need to consider in anticipation of the wells finally being exhausted (or becoming uneconomic to operate).

**Key Words:** Fracking, Hydraulic Fracturing, Economics, Ethics, Value Engineering

## Shale gas and the Practice of Hydraulic Fracturing

US Energy Information Administration (USEIA) (2012) defines shale gas as the natural gas trapped in shale formations, petroleum and gas rich sedimentary rocks; very fine grained sandstone (King 2012). The practice of extracting shale gas [hydraulic fracturing] has been around since the 1940's. And while the practice has been known about since 1800s the first

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hydraulic fracturing (or 'fracking') experiment was carried out in 1947 and the process became commercially viable in the 1950s (King 2012). Hydraulic fracturing is the practice of drilling a well into the core of the shale, at significant depths, sometimes as deep as 2 - 3km (BGS 2011). A high-volume of highly pressurised fluids[frac fluid], a combination of water, sand and chemicals, is used to fracture the shale rock, which allows for the release of the shale gas. The rate of release of the gas is controlled by the use of a proppant, a substance used to keep an induced fracture (or frac) open.

The frac fluid is not a standard fluid, with many companies using a proprietary substances, for which they maintain a 'commercial confidence' right to withhold the full specification. Concerns are expressed that the nature of the proprietary fluids is such that they could harbor hazardous substances (quantities unknown). There are moves by the Environment Protection Agency in USA to have law amended to require companies to fully disclose their safety data sheets, however at present this is voluntary. A report provided to US House of Representatives (2011) concluded;

> *"[Hydraulic fracturing] has opened access to vast domestic reserves of natural gas that could provide an important stepping stone to a clean energy future. Yet questions about the safety of hydraulic fracturing persist, which are compounded by the secrecy surrounding the chemicals used in hydraulic fracturing fluids."*

A study by Cooley and Donnelly (2012) identified a commonality to the broad range of concerns regarding hydraulic fracturing. Acknowledging their small sample size, although happy with the broad nature of the target groups, Cooley and Donnelly (2012) identified that air and water quality featured heavily in list of concerns. Community aesthetics and increased traffic flows were well represented, while worker health and safety and seismic activity barely featured in the list of concerns. Rich (2009) confirmed in an air monitoring study of several locations in the town of DISH, Texas the presence of multiple Recognized and Suspected Human Carcinogens. Rich (2009) concluded that the identified compounds usually associated with industrial processes such as exploration, drilling, flaring and compression common to the natural gas industry. Lechtenbohmer et al (2011), in a report to the European Parliament, were advocating the need for a reassessment of the full impacts from hydraulic fracturing. They concluded that there were a wide range of conceivable accident risks such as; "*blow out with frac-water spills, leakages from wastewater or from fracture fluid ponds or pipes, groundwater contamination due to improper handling or unprofessional cementing of the well casing*" (Lechtenbohmer et al 2011). And these, they argue, could be due to inconvenient handling, increasing economic pressures resulting in a speeding up of the process, which has the potential to decrease due diligence in hazards control with the consequent increase in the frequency of accidents. The USA experience supports such an analysis (Lechtenbohmer et al 2011). However their report was not entirely negative in its conclusions, indicating the authors' belief that these risks can be reduced and probably avoided with adequate technical directives, cautious handling practice and supervision by public authorities (Lechtenbohmer et al 2011).

Ewen et al (2012) in a study carried out by a panel of experts in conjunction with ExxonMobil's hydrofracking dialogue and information dissemination process concluded that there was no need for an outright ban on the practice of hydraulic fracturing. Acknowledging that up until now several unknowns exist with regard to the environmental and health impact of the process Ewen et al (2012) suggest proceeding with caution, not whole scale. The following elements, they argue, are necessary if the process is to proceed; "*a defined state of the art; a legal framework that addresses the new risk dimension entailed by hydrofracking; and additional scientific knowledge*". For the time being, they continued; "*all that should be made possible is exploration of gas fields and realization of single model projects, for which extensive safety precautions should be taken and the scope of investigations and testing should be expanded*". Other studies, not so directly aligned to the oil exploration industry suggest a more cautionary approach, calling for further regulatory controls or an outright ban. Wiseman (2009) argues for a comprehensive national survey the environmental effects of fracing that is scientifically rigorous.

Wiseman (2009), acknowledging the good work being carried out by some of the oil and gas companies as technology advances, suggests that, in the light of such concerns and while studies are in progress, Congress should reconsider exempting fracking from the Safe Drinking Water Act. States should review whether general regulation of the oil and gas industry adequately addresses the potential public health and environmental impacts, Wiseman (2009) also argues. Lechtenbohmer et al (2011) indicated that, "*some risk is inherent to uncontrolled fracturing which results in uncontrolled mobilization of fracture liquids*". For instance, they maintain, it is well known that "*small earthquakes can be induced by hydraulic fracturing which might mobilize gas or fluids through "naturally" created fractures*". Seismic activity was explored, following minor tremors were detected near the Presse Hall well near Blackpool, UK. Green, Styles and Babtie (2012) in their report to the UK's Department of Energy and Climate Change (DECC) acknowledging that the seismic activity could be directly attributed to fracking activities, made the following recommendations;

1. Hydraulic fracturing procedure should invariably include a smaller pre-injection and monitoring stage before the main injection.
2. Hydraulic fracture growth and direction should be monitored during future treatments
3. Future HF operations in this area should be subject to an effective monitoring system that can provide automatic locations and magnitudes of any seismic events in near real-time.
4. Operations should be halted and remedial action instituted, if events of magnitude 0.5 $M_L$ or above are detected.

They further recommended that for any future sites identified for hydraulic fracturing that base line seismic assessments be made prior to any industrial activity commencing. Consequently UK fracking operations are paused (BGS 2011) not banned. UK Government sees no need for a moratorium. This concurs with the work of Williams (2012) where he notes the requirements within the Legislation and Policy Framework for the Queensland Government. It is a requirement that notification be given to landowners prior to commencing and after cessation of operations and that that notice, as well as specifying the chemicals used and the volume of same, must also provide details of completed seismic surveys.

Worker health and safety is largely under represented in the research carried out into the hydraulic fracturing industry operations thus far. Health and Safety Executive (HSE) in the UK have regulatory responsibility for well design and construction, which among other things requires independent verification of the well design. Further scrutiny is afforded through local planning process, the environmental protection agency's consideration of environmental impacts, and the obligation on operators to disclose the content of their fracing fluids. However with issues of public health to the fore along side environmental concerns it is remiss to exclude the health and the safety of those at the 'coal-face'. Bernard Goldstein, a professor in the Graduate School of Public Health at the University of Pittsburgh (cited in Schmidt, 2011) says, "*...published epidemiologic studies relating shale gas production to health are virtually nonexistent*". There are many hazards identified to which the degree of exposure and the extent of appropriate hazards controls ought to be addressed. The Royal Society and the Royal Academy of Engineering (RAE) (2012) consider that health, safety and environmental risks "*can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation*". RAE (2012) suggest a means of collating and sharing best practice information, the engagement of the regulatory authorities (in UK) and support the use of the Research Councils to further research. The unfortunate omission in the list of priorities was worker health and safety as they suggest research should include "*the public acceptability of the extraction and use of shale gas in the context of UK policies on climate change, energy and the wider economy*" (Royal Society and RAE, 2012). As the debate into fracking progresses and the decision as to whether it should continue research into the ability to control worker safety and health by engineering controls and through managerial procedures must take a higher priority. Such due diligence is a fundamental aspect of the engineers' code of ethics, enshrined in the International Engineering Alliance (IEA)'s Washington, Sydney and Dublin Accords (IEA 1989, 2001, 2002).

## Workplace Hazards Associated with Hydraulic Fracturing

### Respirable Crystalline Silica and other Health Hazards

In reviews of occupational safety and health hazards associated with hydraulic fracturing, health and in particular worker exposure to respirable crystalline silica was the dominant hazard discussed. Crystalline has long been recognized as a carcinogen (NIOSH 2010). To cause lasting damage the form of silica must be of a respirable particle size to enter the deep lung. The United States Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) have identified respirable crystalline silica as a worker health hazard during the hydraulic fracturing processes (OSHA, 2012; Esswein et al., 2012b). NIOSH began their worker health exposure characterization effort in January 2010 (NIOSH, 2010). OSHA regulates exposures to crystalline silica via a Permissible Exposure Limit (PEL). Because OSHA PEL's are not updated frequently, NIOSH produces a Recommended Exposure Limit (REL) based on more current toxicological data; thus the REL is more stringent than the OSHA's PEL. In a recent personal air sampling research, Esswein et al. (2012a) took 116 employee breathing zone samples for respirable crystalline silica at 11 hydraulic fracturing sites and found 47% above the OSHA PEL and 79% above the NIOSH REL. In addition they found that 31% of thise surveyed were 10 times above the NIOSH REL (Esswein et al., 2012b).

Esswein et al. (2012a) found that sand can be used in amounts up to 4 million pounds per well, and exposures occurring mostly in cementing jobs, sand transferring, and sand loading. From a review of the Esswein et al.'s presentation (2012a) and the OSHA and NIOSH reports, it does not appear these are new operations. In other words, the fracturing process is simply using a known carcinogen in traditional ways (cementing, transferring, and loading). Hydraulic fracturing operations need to utilize occupational safety and health range of control to solve this known problem. Esswein et al. (2012a) also found worker exposures to other chemicals during the hydraulic fracturing process including the following: diesel particulate; volatile organic compounds; hydrogen sulfide (H2S); hydrochloric acid gas; aldehydes; and lead. Although in their report, it is not clear whether overexposures existed to these substances occurred in any of the worker's personal breathing zones (Esswein et al. 2012a). The findings and recommendations focused on repairable crystalline silica.

### Site clearance / preparation

Before drilling and extraction processes the site must be cleared and prepared for heavy equipment to install the hydraulic fracturing systems. Pipelines might also be installed. Potential worker safety and health hazards in this stage would be indicative of those associated with forestry operations, logging, site grading, and trenching (Marcellus Shale Corporation, 2012).

### Hydraulic Fracturing Processes / Construction of wells

No specific literature or reports have been found that focus on worker safety hazards specific to the installation of the hydraulic fracturing process, its operation, or decommissioning. The safety and risks of these operations must be further studied to determine if new or unique hazards exist and to recommend control measures to the industry. From a review of the fracturing processes, the risks of explosions, and the general exposures to heavy equipment and truck traffic risks exist. It is not known whether these are increased compared to general mining and construction activities. Injury attorneys are naturally seeking to get in on the hydraulic fracturing business. For example, one attorney in Pennsylvania, where the large Marcellus gas deposit sits, focuses on injuries and recognizes that the rush for the gas can contribute to worker fatigue. From their website, "The Marcellus Shale gas rush has made a lot of money for the oil and gas companies, as well as local contractors and workers in the fracking industry. Yet too often, worker safety is a secondary concern when there is so much pressure to work fast and keep the gas flowing (Huber and Palsir, 2012). They label these accidents, "*fraccidents*", and go on to describe two recent claims. They "*represented a worker who fell from a ladder onto a drilling unit, resulting in an elbow displacement fracture. In another case, piping was tied down with a snap binder so tight that it exploded in our client's face, causing an orbital socket injury and brain trauma*" (Huber and Palsir, 2012).

## Ethics Reflections on Hydraulic Fracturing

Following on from the financial scandals of the early 2000s that saw the collapse of several large financial institutions, [Enron, Worldcom, Anderson] corporations are expected to conduct their affairs in an ethical manner taking into consideration the interests of all their stakeholders, not solely those of the shareholders. To this end the Organisation for Economic Cooperation and Development (OECD) issued in 2004 their Principles for Corporate Governance, which over the subsequent years has come to be the guide for all types of corporations and businesses on their financial and societal obligations. The obligation to manage the affairs of the hydraulic fracturing business, like any other business, in a sustainable manner that ensures continued economic success and growth in the interests both of the company and of the nation is at the core, but in parallel is an ethical obligation to those who are effected by the undertakings of the business; namely customers, employees, the communities in which the business operates, the state and in relevant cases the wider society when it is effected by what the business does or fails to do.

Ethical codes are now a common place in many businesses whether stated as core values, a statement of ethics, or other policy on financial integrity, corporate social responsibility or environmental commitment. The validity of an ethics code is tested against three criteria; that the code, in the context of the whole of the business is self-consistent, that it is good for humanity (Fromm 1947) and that it is capable of universalisation, (Crain 1985, Eckensberger 2007). Self-consistency requires that there are no logical contradictions arising from the various elements of the code, including the company's policies, objectives and mission statements. The fact that a company does not adhere to its own code is not a negation of the self-consistency of that code, but rather evidence of non-compliance and unethical behaviour by the company. Contradictions arise for example when the legal requirements of contracts of employment conflict with the professional duties of engineers to prioritise their obligations to the wider society (IEA Accords 1989, 2001, 2002). Companies expect and reward loyalty and it is considered good ethical behaviour to work (in full compliance with the law) in the interests of the employer. But when the interests of the employer is not fully accepted by the communities in which they operate, professionals seek ways to mitigate the contradiction between conflicting duties. The EUCI Conference on Engineering and Technology Developments (2012) included an agenda item to explore potential risk management strategies with the aim of avoiding costly permitting delays and for reducing potential litigation risks. Though the outcomes of such deliberations may lead to strategies that will benefit external stakeholders and the environments, the terminology used clearly implied an economic objective on behalf of the extraction companies and that any benefits to other stakeholders or the environment would be incidental. The function of ethics is that it is concerned with guiding behaviour such that at its most basic it will not harm others and in its more evolved forms actively contributes to the good of others. The OECD principles at their core aims to have companies behave with financial integrity and in the interests of their shareholders. But they recognise too that companies in their undertakings have an impact on other stakeholders and that these interests must be considered and acted upon whenever harm is a real outcome. The more directly affected by the undertakings of a company the more their interests become of immediate concern. The nature and extend of the undertakings of the extraction companies is such that large population centres, extensive rural communities, underground and surface water sources extending tens and hundreds of miles from well and quarrying activities are all effected (Blohm et al. 2012, Haworth et al. 2012) and that the key stakeholders constitute a substantial proportion of the current and future populations in countries where these activities are undertaken.

There is evidence that the economic and social advantages to be gained from coal-bed methane extraction (CBM) will be extensive. Many $billions will be generated, tens of thousands of jobs will be created and a key political issue will be energy security for the next generation, (Considine et al. 2011, Tieman et al. 2012). However when these economic benefits compete with public concerns about water contamination, landscape destruction and air pollution (Haworth et al. 2012, Osborn et al. 2011) it is not sufficient to pour money into lobbying the law-makers to pass legislation that favours the extraction companies to the detriment of the interests of local communities. In 2011 a single extraction company spent $1.09m on a single issue compared to $480,000 by the Citizens Campaign for the Environment on all their lobbying issues, (Lerner 2011, Browning & Kaplan 2011). Disproportionate expenditure on lobbying may benefit the shareholder but it leaves the remainder of the key stakeholders to live with the consequences. In Australia one organisation views coal-seam gas (CSG) as but another activity on the land and in the landscape that requires management (Williams 2012). Recognising the potential significant negative impact on water resources, and that protection of the biodiversity and landscape is critical but a neglected national resource issue their proposals are that CSG production and agricultural and forestry protection needs to be approached holistically and managed as part of whole landscape planning, (Williams 2012). There is an element of realism here that recognises that gas extraction is going to be part of the immediate future but that it should not be carried out in isolation from other human activities and needs in respect of the environment, but integrated fully within national biodiversity and social protection measures. Where harm, real and alleged, has occurred independent, objective assessments are required that will determine the nature of the harm, its causes and what will be required to remedy the situation and prevent reoccurrences. The causes of the earthquakes in 2011 near Blackpool, UK, thought o be attributed to direct fuel injection into adjacent fault zones during treatment projected a low probability for further earthquakes. Green, Styles and Baptize (2012) were unconvinced of these projections basing their conclusions on the fact that the earlier reports had failed to identify a causative fault and that details knowledge of faulting in the area was poor. The recent jailing of Italian scientists (Halsbury's Law Exchange 2012) for failing to predict earthquakes is a salutary lesson that competent objective assessments uninfluenced by political or economic considerations is the minimum that is to be expected from companies and their consultants.

Failure to properly examine the concerns of effected communities and allow extraction practices to continue without adequate regulation will not satisfy the complainant, even when the democratic organs have carried out the assessments. The US's Environment Protection Agency report (2004) into contamination of underground sources of drinking water (USDW) concluded that injection of hydraulic fracturing fluids into CBM wells poses little or no threat to USDWs and that there was no justification of further study at that time. In respect of complaints of contamination, they saw no conclusive evidence that water quality degradation was due to hydraulic fracturing, but that several other sources may be responsible. That report was based on existing literature and on incidents complaints of drinking well contamination. An objective specific study focussing on the particular issue was not commissioned, however by 2011, when over 1,000 complaints had been received the EPA was required by government to fund a new study to examine cases of contamination, (Lerner 2011). A mature ethic requires that where harm is occurring or is alleged, studies into the causes must have as a priority the interests of those on whom the harm is falling. Failures in this regard or partisan approaches to investigations is a negation of ethical behaviour and of the positive economic opportunities presented by they processes.

Ultimately, a code of ethical behaviour must have universalisability, namely that it underscores the fundamental value of equal existence (Kohlberg, cited in Crain 1985) and recognising that that takes precedence over claims to property or wealth rights, or of national energy security issues. Such rights and issues gain validity only in the context of being subordinate to achieving universal equal existence. In this respect it is incumbent upon the industry to consider in their impact assessments how this is to be achieved, how the environment is to be protected, how contamination of the water and air resources is to be prevented and how the production of gases is to contribute to human welfare and sustainability.

## Economic Reflections on Hydraulic Fracturing

The extraction of natural gas from shale formations is one of the fastest growing trends in American on-shore domestic oil and gas production (Ground Water Protection Council, cited in Jackson et al 2011). USEIA (2011) estimate that there is 750 trillion cubic feet (tcf) of technically recoverable shale gas resources in 3 regions of USA, North East, Gulf Coast and South West. These current figures [2011] greatly expand previous estimates where it was reported (Moss 2008) that 31 tcf might be recoverable from the Marcellus formation in North East Region of USA, compared with INTEK's estimate or 410 tcf (cited in USEIA 2011). Williams, Stubbs and Milligan (2012) report that while Australia has large coal seam gas [shale gas] potential, exploration is in its infancy consequently resources are, as yet, poorly understood and quantified. Nevertheless Queensland Government has indicated that in their state alone the coal seam gas [shale gas] industry will generate over 18,000 jobs and net annual royalties in the order of AUD$850m. In UK British Geological Survey (BGS) (2011) has estimated the UK shale gas reserve potential could be as large as 5.3 TCF.

Priddle (2012) reports "*producing unconventional gas is an intensive industrial process, generally imposing a larger environmental footprint than conventional gas development*". Often more wells are needed and hydraulic fracturing is usually required to boost the flow of gas from the well. In the face of all predictions of economic prosperity offered by hydraulic fracturing the diverse nature of economic benefits claimed the discussion, kept simple, can be advanced by asking the '5W' questions from an economic perspective, namely, Why, What, When, Where and Who. An intriguing tapestry regarding fracking can be created from the simplest premise;

1. Why fracking, well why not?
2. What can fracking provide for humanity from an economic perspective?
3. When will the costs and benefits of fracking be realised?
4. Where does the value to humanity lie in the practice of fracking?
5. Who are the potential winners and losers from the practice?

Why Fracking or similarly why Nuclear or any other form of energy provision; all have potential repercussions if they go wrong but the argument for the use of fracking is that even though it is potentially risky the potential benefits can be argued to far outweigh the potential costs. Considine et al (2011) argues that the US has shale gas reserves large enough to satisfy US demand for decades or centuries to come. The report also postulates that the support activities such as steel, sand and gravel supply and engineering services to the shale gas extraction projects are not easily outsourced to foreign suppliers so the local economy and workforce is largely going to benefit. Considine et al (2011) concludes that shale gas production can offer regions a stream of revenues that doesn't quickly dry up quoting figures of $4,000,000 on average in economic benefits from each well. Compare this with Lechtenbohmer et al (2011) report for the European Parliament that concludes that in a time when sustainability is key it should be questioned whether the injection of toxic chemicals into the ground should be allowed or banned in Europe. This is further reinforced in that the report also indicates that the potential shale gas plays are too small to have an impact on the European gas supply.

This brings the discussion to Cost Benefit Analysis (CBA) as a means of justifying the practice. Who prepares the CBA and for whose benefit and at whose cost? It could be argued that potentially the organisation that prepares the CBA may not be able to be truly impartial due to the specialist nature of the practice. Lechtenbohmer et al (2011) argue that Life Cycle Analysis (LCA) should be mandatory and that consideration should be given to including a CBA as compulsory based on an extensive LCA for each individual project. This they maintain is necessary to demonstrate the benefits for society as a whole.

This also brings to the fore the point of value for money and return on investment (ROI). No government or organisation no matter how wholesome the image they appear to present, are in the business of not getting value for money and a ROI that matches or exceeds their shareholders or voters expectations. Fracking from a headline point of view seems to have very few friends around the world but it is no accident that those who generally are in favour of the practice are those who will benefit financially. Taking a generalist big picture viewpoint on Considine et al (2010) and Lechtenbohmer et al (2011) are at opposite ends of the spectrum, with Considine et al (2010) arguing from a US standpoint, very much in favour of the benefits of and apparent lack of environmental costs of fracking. Lechtenbohmer et al (2011) posting a more guarded cautious approach to fracking within the European Union, concluding that the large gaps in EU regulation with regards to fracking need to be addressed before any decision to move forward in a substantive manner and also highlighting the need for full awareness of the potential massive environmental and human impacts. The US based report (Considine et al 2010) on the other hand whilst identifying possible environmental impacts considers them as such a low risk that when applying CBA techniques they indicate an average cost of $14,000 per well as opposed to $4million of benefits per well. However there is insufficient evidence to corroborate these assertions. The key final recommendation from Lechtenbohmer et al (2011) was with regards to much tighter regulation to reduce the possible costs to the environment and population to a minimum. Lechtenbohmer et al (2011, p.79) concluded that;

> *"Because of the complex nature of possible impacts and risks to the environment and to human health of hydraulic fracturing, consideration should be given to developing a new directive at European level regulating all issues in this area comprehensively".*

One final question is how two relatively opposing viewpoints can exist on the same process, which is simple to answer on the premise that there are a least three sides to every story, namely, the for side, the against side and the real truth somewhere in between. Ultimately then where does the economic truth with regards to fracking lie?

## Future Research

The list of questions under each heading could be virtually endless but this only goes to reinforce the need for further critical research into the field of hydraulic fracturing from OSH, ethics and economics perspective. Not surprisingly this preliminary scoping exercise has raised more questions than answers which from a review of the existing knowledge of fracking practices appears to be a practice that for Governments deciding on whether to develop their Fracking agendas should take time to consider and demand independent answers on a case by case basis. Fracking is certainly not a process where one approach fits all or benefits all localities and communities with or without appropriate regulation.

Compared to worker health, there appears to be a gap in worker safety research during the preparation, installation, and operation of hydraulic fracturing processes. The safety and risks of these operations must be further studied to determine if new or unique hazards exist and to recommend control measures to the industry. Researchers should seek opportunities to work with drilling companies, developers, and workers to adequately describe the nature of safety related hazards and risks in hydraulic fracturing and through a consideration, using the established approaches to prevention through design, value engineering/ CBA and cultural maturity indexing establish the efficacy of elimination or mitigation of OSH hazards. Research should focus on equipment manufacturers and the design of individual wells. In the interim engineering controls, training, and enhanced procedures should be developed and communicated within the industry.

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**The application of deductive logic to determine the objective conditions impacting upon cultural maturity**


## Abstract

*A competent company has a level of cultural maturity wherein its strategy, managerial structures and policies, and the way in which it acts all converge to ensure that it meets its responsibilities to its workforce and those affected by what it does. Culture is the way in which the company behaves regarding critical business factors, including safety, and maturity is the ability of the company to react, handle difficult situations and reason in an appropriate way in each situation in the achievement of its objectives. All to often it is 'safety culture' that becomes the metric and this research contends that rather than focus on one aspect of culture it is the 'cultural maturity 'of an organisation that is the most authentic reflection of its competence and one of the most powerful elements affecting its long term success.*

*The signing of the Seoul Declaration on Safety and Health at Work combined safety and health of the workforce with human rights as enshrined in the UN Declaration on Human Rights; the effect being that safety must not be treated as an adjunct that can be added to or subtracted from the work process according to how well the 'bottom line' is doing. Accordingly, determining the status of an organisation's cultural maturity affects its development and future growth in the context of its social and human obligations, boosting safety performance in concert with business performance.*

*This paper describes the developmental research associated with the production of a diagnostic tool that measures the cultural maturity of an organisation with specific emphasis on qualifying the leadership competencies emerging from policies and practices. The research output is a diagnostic tool that analyses the apparently immeasurable intangibles of organisational culture to produce tangible and significant performance improvement solutions in a safe and sustainable manner.*


## Background

For many companies, coming to terms with the requirements of the Health and Safety at Work (HASAW) Act 1974 or the HASAW (NI) Order 1978 meant a long period of learning. Perhaps it would be more accurate to say that it took a long time to develop an understanding of the main requirements of the health and safety legislation. One of the key ideas in the production of the new legislation was the desire to replace the mass of existing legislation with one single Act that would apply to all workers. The prime obligation for employers was to be aware of all the hazards associated with their industry and to put in place sufficient control measures to protect their workforce. While the principle was sound, the practice and degree of compliance varied significantly across the UK and across the different industry sectors (McAleenan and Orr 1999). The development of a Single European Market in the early 1990s brought more challenges. Differing standards and legislative requirements across the European Union (EU) member states were so significant that the potential for cross-community competition was seriously impaired. Accordingly the EU took steps to address the issues raised by this situation and at the same time give a renewed impetus to the direction that occupational safety and health should be taking. The direct effect of EU intervention was to make explicit that which had been implied in the original HASAW legislation in UK and in particular, the new legal requirements placed risk assessment at the heart of health and safety management. Further in USA, although faced with a different emphasis, absolute requirements to act according to Federal Regulation, businesses were faced with similar risk managed approaches to operational safety. Despite the sizeable regulatory position in each of the jurisdictions the problem remained; accidents were occurring in substantial numbers, while the focus in business appeared to be centred on the consequential paperwork. And while the risk assessment/risk management approach did have some successes in the early to mid 1990s it appeared to have reached an equilibrium, that would not be breached so long as the bureaucracy, spawned since the enabling of the regulations, remained the dominant preoccupation (Works and Pensions Committee 2008). Since 1941, the International Labour Office has collected statistics on occupational injuries for publication in the Yearbook of Labour Statistics and while in 2002 (ILO 2002) they freely acknowledged that the reporting mechanism was unreliable and that they were working on estimates that they believed were grossly underestimated. The global fatality rate for workplace accidents and occupational diseases was estimated to be:

- 1.2m work-related deaths;
- 250m accidents; and
- 160m work-related diseases.

Later improvements in the reporting mechanism and returns from a greater number of countries have the most recent figure at 2.3m (ILO 2011). Risk assessment and more particularly risk management failed to produce the critical mass needed to deliver a safe and healthy global workplace. What appeared to be the resultant popular opinion was that there was an acceptable level of risk and while no one was likely to explicitly state they would accept fatalities in their operations the actions, demonstrated by the approach to safety, coupled with the global fatality statistics would appear to suggest otherwise. It would be unfair to suggest there was a widespread callous attitude to safety; rather the extent and the scale of the problem demonstrated an urgent need for initiatives that could reverse the current upward trends in work related accidents and occupational diseases. The authors, recognising the problem and acknowledging its extent, embarked upon the research presented in this paper with the intention of offering an alternative. The aim of the research was to demonstrate how the application of dialogics develops critical consciousness, providing the intellectual capacity to know how to safely control workplace operations and in the process establish links between competence, cultural maturity and ethics reasoning.

## Rationale

Gramsci, (cited in Löwy, 2011) used, for the first time, the expression "philosophy of praxis", which Löwy (2011) perceived as defining Marx as a worldview. The philosophy of praxis, practiced in workplace safety and health sets a standard far beyond the quality paradigm in as much as quality relies upon a rigid consistency of approach to deliver a predetermined outcome (product or service), same way, same thing, every time. Where praxis has some similarities with Deming (1986), Juran (1998) and Crosby (1979) is in its adherence to planning and control, however the essential difference, and what sets it apart is the critical reflection at each point of checking reflecting that change has already taken place and the journey may have changed also (Figure 1). The rigidity within the quality models exposes their fixation with consistency of approach regardless of whether the direction is right, failing to contextualise with society other than as a commodity. Profit drives the change and in that rests the question, where is the societal responsibility? It is not necessarily about doing things wrongly rather it could be about doing the wrong things. Dialogics on the other hand recognises society as an integral aspect of what is produced. It is not an abstract concept, rather it establishes that workers analyse the impact of the work on themselves, their colleagues and calls upon them to consider the wider harm the work and/or the product might have on society.

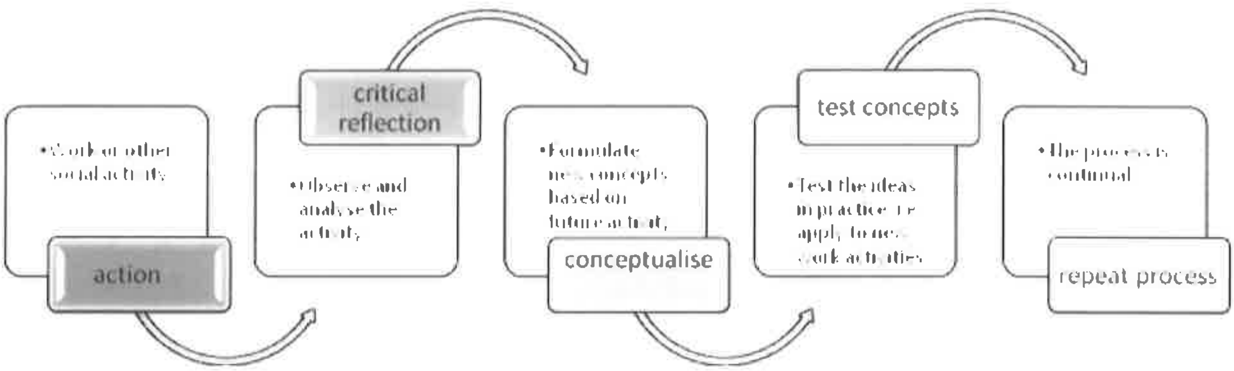


Figure 1: The [Authors] Praxis Model for OSH Management

At the extreme the munitions worker, the tobacco plantation worker or the operative on the line at the cigarette factory all have a role in analysing the degree of harm they are likely to be exposed to, but what of the harmful effects of the end product. For them harm comes in many ways and protection of their livelihood will determine the objective meaning behind decisions they make. This presents a sense of powerlessness/alienation in the workers, until through the praxis approach they grasp the opportunity to recognise and address some of the dilemmas of competing objectives (McAleenan and McAleenan 2010b). Factory or plantation owners however have a chance to explore the societal aspects of the praxis model.

**Operation Analysis and Control approach**

The Operation Analysis and Control (OAC) approach (McAleenan and McAleenan 2002), based on the premise that work activities must be viewed and carried out holistically with no unnecessary separation and devolvement of functions to others, particularly in the realm of critical decision making vis-a-vis safety. With OAC the authors are not interested in reducing the risk, rather the case is presented for managing any operation in any hazardous environments such that with full knowledge of all the hazards and of the necessary control measures there is no risk. Managing risk is balancing (or trading off) the knowns with the unknowns in the expectation of a successful outcome. If safety, not the risk, is managed and the safety of the operation is controlled, i.e all hazards and the appropriates controls are in alignment, then it does not matter how hazardous the environment is since, with OAC, the operation itself is non-hazardous and the outcome will always be non-injurious.

As the OAC approach was being introduced to businesses (McAleenan and Orr, 1999, McAleenan and McAleenan 2002. Ayers and McAleenan 2008) it was being refined through regular presentations to gatherings of professional bodies; safety, construction, engineering and academic. Each refinement was a logical development of preceding concepts, starting with the holistic approach to workplace safety, through the application of the principles of effectiveness to work management, to the rational re-integration of responsibility and authority to make decisions related to the work being undertaken. In the process it has become apparent that realistic considerations of work activities must see them in context, not simply of their relationship to other activities on the shop floor or construction site, nor indeed of their context within the overall company in which they occur, but also in the context of their wider affect on social and environmental matters; locally, nationally and globally. The twin objectives for the sustainability of any business is for its activities to be good for the individual worker and good for the company and in this we have echoes of Fromm (1947) contends that what is fundamentally good for the individual must, of necessity, be good for humanity.

**Seoul and CULTURAL MATURITY**

The third paradigm in the Seoul Declaration (ILO 2008) states:

> "*occupational safety and health requires a fundamental conceptual shift towards the creation of a culture enhancing workers' well-being and welfare, away from a myopic focus on responsive accident-prevention activities*"

Sir John Egan (1998) reporting to UK's Deputy Prime Minister on the state of the construction industry specified that; "*If the industry is to achieve its full potential, substantial changes in its culture and structure are also required to support improvement...*" In recognition of this McAleenan and McAleenan (2010b) concluded that "*An evolved company is one that has the intellectual and technological capabilities to prevent workplace accidents and at the same time achieve its objectives without being risk averse*". Previously McAleenan and McAleenan (2009) had discussed the link between competent companies and cultural maturity, in the context of the Seoul Declaration (ILO 2008). Until then OAC never had a specific audit tool since it was not some new management system to sit on top of all other management systems, rather it is an approach or thought process, which readily integrates with whatever management style exists in the company, flexible enough to adapt to any style and robust enough to stay the pace. Once embedded in the company it can be measured against any of the international management specifications; quality, environmental or safety; including ILO-OSH guidelines (ILO 2001).

However the discourse, associated with the third paradigm, took OAC to another level and to the refinement of preexisting diagnostic tools (McAleenan and McAleenan 2009) to allow organisational cultural maturity to be addressed and measured. Delving into the intent behind the third paradigm and exploring some of the relevant definitions the following is held to be true:

- A competent company is one wherein the strategy, the managerial structures, polices and the way in which the company acts to meet its responsibilities towards all the stakeholders combine in a way that; ensures the safety of its workforce and those affected by what the company does, enhances the quality of its output, and satisfies the fiscal needs of the owners in a sustainable manner.
- Workplace Culture is the way in which the company behaves regarding critical factors such as safety, sustainability and stakeholder rights, and the structure is the way in which it organises itself to achieve its objectives.
- Quality companies demand exemplary work practices and excellent conditions throughout and to obtain these assess how competence is viewed and practiced.
- Cultural maturity is when a company demonstrates that it has the necessary attributes essential to achieving success in health and safety, productivity and meeting its obligations towards all its stakeholders.

However in Seoul (ILO 2008) and with the emergence of behaviour based safety (BBS) interventions as a management tool there was clearly a need to create a diagnostic tool that would allow companies to measure the success of their programmes while they are developing, not at the end by calculating the accident frequency rate and comparing it with pre-intervention levels. These kinds of measurements have traditionally been the favoured approach because they are considered tangible and anything associated with human behaviours such as BBS interventions are deemed intangible. The diagnosis of organisation cultural maturity described in McAleenan and McAleenan (2009) is a thorough examination of leadership roles, responsibilities and actions measured against the policies and practices within a organisation providing a tangible measure of what is normally considered to be the intangibles in the management system. This approach brings the focus onto the positive effects of both the tangible and intangible activities of an organisation and the measurement is in the form of a leading indicator, measuring successful interventions and activities as they occur.

### Linking OAC to Organisation Cultural Maturity Index

At the 2008 World Congress in Seoul it was reiterated that safety and good health at work is a fundamental human right enshrined in the United Nations Declaration on Human Rights (1948). The research at this stage brought into focus the early work on culture, leadership and the value of partnerships in delivering a successful and safe work outcome (Ayers and McAleenan 2008). The discourse is further advanced in the work of Behm et al (2009) where the discussion focusses on green and sustainable design which has emerged from ethical considerations about what is good for the environment and ultimately what is good for humanity. However when it comes to ethical design the values which guide the designer are founded in technical and engineering codes of practice and codes of conduct which appear fixed and stemming from higher professional authority rather than from an objective science. The authors makes the case for the inclusion of a science of humanity in academic and professional studies as the foundation of the art and practice of ethical design (McAleenan and McAleenan 2009a, 2009b and 2010a). It is argued that only by understanding what human nature is and how we make determinations about what is good (and bad) for others and ourselves can we can develop an ethical approach to what we design, build, maintain or operate. This hypothesis deepens our understanding of competence, culture and ultimately leadership in the delivery of a safe and healthy product or service. As with good engineering or sustainable designs ethical design tends towards the construction of projects that are good for humanity in a holistic sense. Since the signing of the Seoul Declaration (2008) the authors research focus turned towards the emerging themes of competence (in its widest sense), culture, organisational maturity governance and ethical responses. The objective being to explore range of techniques available to aid the development of competency within the company and in the process develop diagnostic tools to help build appropriate structures that meet the objectives of the Seoul Declaration (McAleenan and McAleenan 2009a). The authors used exemplar models, case studies, direct experience and innovative ideas that would allow practitioners to address workplace dynamics, their role within those dynamics and open a discussion of the options available to transform their company into one that advocates a competent and preventive culture (embedded throughout international declarations and protocols). Since good policy needs a clear definition of the problem(s) and a good explanation of how the policy will fix it then businesses need a diagnostic tool that will assist the process. All too often businesses jump straight to the remedy (e.g. behavior-based safety (BBS) programmes) rather than getting to the root cause of their problem. Also with initiatives such as BBS the belief at the time was that many of the ensuing benefits were intangible and consequently not measurable, until some years down the line where a more tangible variable could be used to measure the success of the initiative. The result being the introduction of initiatives in hope that somewhere down the line success can be measured in, for example a reduced number of accidents. This focus in lagging and negative indicators betrays good strategic business practice and was the challenge of this research. The developed toolkit (Version 1) named, the Organisation Cultural Maturity Index (OCMI), is an iteration of a model in operation across other disciplines (outwith the health and safety field), in which the authors have been engaged over the years; determining non-monetary [intangible] costs and benefits in community projects.

The OCMI diagnostic tool measures and presents in numerical terms both tangible and intangible performance indicators, allowing business to target improvement strategies that are appropriate for their strategic needs and are in line with their organisation's culture. In developing and implementing OAC processes within a company there are core maturity criteria, the absence of one or more could severely impair the company's sustainability and impact negatively on its ability to remain viable, relative to competitors in times of economic stability. The maturity criteria are;

- Corporate Social Responsibility (CSR): competent company is aware of and acts to meet its responsibilities towards all the key stakeholders, including society, customers, community, workers and owners,
- Innovation: the company is innovatory with the ability to diversify and transfer skills to the development of new products and outputs,
- Resourcefulness: the company can use existing human, material and financial resources in a creative and adaptive manner to meet the challenges of changing social and economic conditions, and

- Authority: the company encourages self-managing units in which individuals and teams have the authority to make decisions within the sphere of their control and influence.

If the culture of a company is deficient in or indeed missing one or more of these criteria it runs the risk of failing to compete in the market place against competitors who are stronger in these areas or leaves itself vulnerable to prosecution for breaches of statutory duty, closed out of markets for failure to innovate and, in respect of having 'too authoritarian an approach to management', is likely to fall foul of the declarations and conventions on safety and health at work. Having selected the criteria the task was to design a way to objectively assess how a company demonstrates that it possesses the cultural attributes essential to successfully establishing preventive measures regarding occupational safety and health. The challenge is to put in place a system that will measure and monitor an organisation's behaviour and competence and present the findings in a consistently objective manner. Once the weighting of the maturity criteria have been established, when consistently applied year on year objectively compares the growth in cultural maturity of the company. OCMI is designed to be able to deliver an in depth analysis by interrogating and measuring a range of verifiable sources including the policies and practices within a company; using direct observation, horizontal/vertical slice interviews and desktop studies of relevant paperwork and assigns a range of scores to a number of capabilities, linked to the maturity criteria (Table 1), which places the company on a maturity rating from 1–100%.

Table 1: OCMI - Cultural Maturity Rating (Example)

Company Name: Company Contact Details:

| | Maturity criteria for a competent company | | | | | | |
|---|---|---|---|---|---|---|---|
| **Core Capabilities** (In respect of Safety Culture) | CSR | Innovation | Resourcefulness | Authority | Score Average | Weighted multiplier | Multiplied score |
| Leadership | 6 | 8 | 4 | -1 | 4.25 | 10 | 42.5 |
| Collaborative Working | 3 | 6 | 5 | 9 | 5.75 | 5 | 28.75 |
| Working Safely | 6 | 3 | 2 | 8 | 4.75 | 10 | 47.5 |
| Using Management Standards | 5 | 6 | 7 | 8 | 6.5 | 5 | 32.5 |
| Developing People | 8 | 7 | 6 | 5 | 6.5 | 8 | 52 |
| Managing Operations, Project Controls | 3 | 2 | 8 | 8 | 5.25 | 5 | 26.25 |
| Reporting Effectively | 6 | 7 | 8 | 5 | 6.5 | 10 | 65 |
| Incentivising Behaviour | 7 | 3 | 2 | 8 | 5 | 5 | 25 |
| Defining Objectives | 8 | 6 | 7 | 8 | 7.25 | 8 | 58 |
| Setting & Managing Budgets, Establishing human/material/financial resources | 5 | 7 | 6 | 5 | 5.75 | 5 | 28.75 |
| | | | | | Totals | 71 | 406.25 |
| | | | | | Maturity Rating | | 57.22 % |

OCMI was piloted in a UK consulting firm and has been scrutinised by a number of key players in Canadian oil and gas industry and is considered to be the right tool coming at the right time for industry. The pilot study, among other findings, allayed concerns regarding the integration of OCMI into existing company safety approaches, such as perception surveys, climates studies. Additional findings derived the following:

- The knowledge gained would supplement or augment company activity to help advance safety performance improvements. By creating a baseline for improvement and putting a tangible rating to an otherwise intangible activity adds value to the safety management system.
- Through an examination of the material facts and a critique of the consequences of what interview respondents say (or don't say) can establish whether the talent in the company is in the appropriate position and the degree of effort needed to deliver the company safety vision and whether there is duplication, conflict or contradiction of effort.
- The analysis gets to the root cause of problems and identifies how attitudes, behaviors and how the job might need to change so the company retains it's legal obligations and safety vision (by departmental or across the whole company).

The pilot company owner followed up the diagnosis with the following statement:

> *"Whilst striving hard to meet shareholder and stakeholder needs, approaching this ethically and with full support of my team is vitally important. [Authors] conducted an organisationally centred study using OCMI which proved to be a real eye opener. Its primary strength is to create a clear view of reality, from multiple perspectives enabling contemporary managers to make informed decisions on every facet of their business..."*

## Conclusion

As the workers become more aware of, move toward greater understanding of and ultimately take control of their decision making; a raising of consciousness, then power becomes more evenly distributed. The employer/employee; tell/do attitudes can be eradicated from the world of work, replaced by a more socially aware and responsible organisation; the essence of cultural maturity (McAleenan and McAleenan 2009). The next step in the development of workplace cultural maturity centres not solely on whether a worker goes home as safely and as healthfully as he arrived that morning, but on how the culture of the workplace contributes to the overall benefit of society. OCMI effectively closed the circle of development of the new occupational safety and health management model; a tool now existed that could diagnose the problems (OCMI) and a tool was available to deliver the necessary transformation (OAC).

The research has demonstrated that it is possible to develop a diagnostic tool that analyses the apparently immeasurable intangibles of organisational culture to produce tangible and significant performance improvement solutions in a safe and sustainable manner. As a result of the pilot project and the authors' recent work on ethics reasoning and agency there is a need for refinement to the OCMI diagnostic tool. The current project (OCMI Version 2) is revising the maturity criteria to focus on ethics reasoning, agency, personnel competence and sustainability.

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**Leadership - a negation of agency or an opportunity to develop autonomous action for workplace safety**


**Abstract**

The full development of safety or the achievement of safe progress onsite requires that leadership, as a catalyst, is relinquished in favour of the collective agency of the mature reasoning group, whether the design team or the onsite works teams (Authors, 2009b).

The claim to leadership is valued as it confers authority on the decisions, pronouncements and actions of those regarded as leaders. With it comes respectability and an expectation that those not in the leadership position will defer to the authority of the leading opinion. In some instances the cloak of leadership provides and is actively used as a protective barrier against objections and opposition.

The general concept of leadership is multifaceted and in common parlance has many uses and meanings, (Eacott, 2013 and 2014), from its application to those who are decision makers, to those holding office who assume the role of leader by dint of said office. In some cases leadership is assumed or assigned to those with ownership of or control over large scale enterprises. Intellectual or thought leadership is claimed by other institutions on the basis that they have more members or have greater recognition than comparable bodies.

Leadership has the potential to negate (autonomous) agency, and this is crucial to understanding the limited role that it should have in human affairs in the sphere of occupational health and safety where the decision making capacity of competent workers may be compromised by the overriding decisions of 'safety-leaders' on the periphery of or outside of particular design and construction activities. The full development of an idea or achievement of progress requires that leadership as a catalyst is relinquished in favour of the collective agency of a mature reasoning body.

Using a critical analysis approach this paper investigates the leadership concepts prevailing in the built environment today, arguing that the imposition of a 'safety-leader' negates autonomy and explores how treating leadership as a function, which transfers to those most suited to exercise it, presents the opportunity to develop autonomous actions for workplace safety.


**Aspects of leadership hierarchies**

The professional and academic discourse on leadership is substantial and encompasses a range of conflicting theoretical perspectives (Spoelstra 2013, Eacott 2014) from how it is to be defined to whether leaders are born or made (Mostovicz et al 2009), where it is to be found (Kumar 2012) to what role it has in modern society (Chari 2012, Lowder 2014). A brief examination of a few of the different use to which the term is applied illustrates the complexity of the issue.

In the political sphere the claim leadership is made on the basis of politicians having 1) have more votes than their opponents and 2) they have been voted into office by the electorate. In a survey of business managers prior to the 2010 general election in the UK the ILM concluded that "leadership matters, particularly in politics, where it builds consensus in the party, balances competing agendas and ultimately wins elections", (ILM 2010). This latter point is however a conflation of electoral politics and voting intentions with the electorate's desire to be led by those they vote for and indeed on the basis of the 5 dimensions of leadership the ILM used to determine the "Leadership Quotient" the 3 main party leaders scored rather low compared to other world "leaders" such as Barack Obama and Angela Merkel, nor did the leadership quotient reflect the positions of the three parties in the election.

The referral to Prime Ministers and Presidents as world leaders is based as much if not more on their decision making roles on behalf of their respective countries as it is on their personal share of the vote and their popularity. This conflates their role with the notion that their fellow nationals will follow or agree with their decisions or where the nation are being led. The conflation of decision making roles or positions with leadership is also found in industry where CEOs and senior management are similarly regarded as leaders and in the recruitment process qualities that make up leadership are central to decisions on whether to appoint or not (Fresh Minds, 2010).

It is the case that particular decisions by politicians and CEOs take the country/organisation in a particular direction, but this is not necessarily leadership. Such decision makers have the power and authority to take the country/ organisation along particular routes regardless of the support that they may have or not for the decision. The power relationship between "leader"and "follower" is not often central to the discourse but is evident within the terminology of differing theories; thus whether the leader, as in employer/ manger, controls the follower/ employee through a basic leader-member-exchange (LME) relationship (you do the work I want you to do and I will pay you a wage) (Tummers and Knies 2013) or in a transformational leadership approach the leader support and encourages the growth of subordinates to possibly in turn become leaders/ managers in the company/ organisation, (Latour and Rast 2004) or at least to enjoy their position and be supportive of the company, (Reid ....) the relationship is always one of power, the "followers" are not or not fully equal to the "leader".

These power relationships are expanded in the managerial structures established by organisations and the role or function that individuals are assigned in those structures. Managers, even supervisors are expected to have leadership qualities in order to ensure that the workforce of the 21st century is well managed and that the companies continue to compete successfully in the market, (ILM 2012, IOSH 2010). Part of this is the role that health and safety plays in the success of a company and part of the safety discourse centers on safety leadership and the role of the safety leader, including who is the safety leader. Legislation in the UK mandates companies with boards to appoint a member of the board to have responsibility for ensuring that safety is incorporated into board reports and discussions, thus in the context of the above, ensuring that the leaders of the company are leading safety. The Institution of Occupational Safety and Health (IOSH) views transformational leadership as being more effective in achieving accident prevention an the reduction in unsafe behaviours by employees (IOSH 2010) because they engender trust and respect from employees citing a positive relationship between supervisor's safety leadership styles and employees safety behaviour.

In industry the position of leader and follower parallels the relationships that people have to the means of production. Put simply, you own the company you have the authority to decide how it is to be run and who does what, fundamentally an LME relationship without any sophistication, though in practice it has become much more sophisticated on the back of management and leadership theory. Emergent perspectives on how companies should behave challenge such unrefined approaches to directing and managing organisations and ethical leadership is being promulgated as central to what a leader does (Kumar 2012, Chari 2014, May and Pardey 2013). Ethical leadership theory developed out of the failures of large corporations in the early 2000s, failures that were the result of corruption and illegal practices in the financial world, and ultimately the banking and housing crises that led to the 2008 crash and recession. Organisations, such at the International Labour Organisation, recognised that a recession, particularly if was to be extended, would lead to a decrease in good health and safety practice resulting in more workplace fatalities and injuries and warned of this at the World Congress on Occupational Health and Safety (OSH) in 2008 (Authors 2009b).

Positions of authority based on knowledge and expertise confers leadership status on some, even in situations where the individual is not pro-actively developing a leadership role or function. This happens when the idea or knowledge that an individual has gains wider support from others who take up those thoughts with the intention of putting them into practice or in some instances developing them further. There is no doubt that when an idea is published there is some element of wanting others to take it up but without an active programme of subordinating followers to the originators ongoing thoughts on the matter, leadership here is defined primarily by the nature and actions of the followers.

The expert as a leader, active or passive, is not a new concept but Thought Leadership is. Leaders Direct (2014) defines is as being "radically different from traditional top-down leadership. It can be directed up as well as down or sideways, has nothing to do with position or managing people, is the basis of innovative change and is egalitarian because it can shift rapidly from one person to another". In this respect they state that it is not something that can be monopolised yet is is none the less an aspiration or an objective that some organisations strive of towards and in the process it becomes commodified; IOSH for examples views the provision of high quality guidance as a key part of the organisation's thought leadership and corporate social responsibility activities. [1]

**The necessity of agency**

The idea that the concept of leadership means in some instances to guide and direct, in others cases to be to the fore or to be the best in the field, and in still others to be in advance of others who willingly follow, has merit, but limited in that for much of the time what is seen as leadership is in effect aspects of managerialism, that is people in senior positions in organisations are charged with an objective that requires they organise others

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[1] IOSH. Membership Advisory Panels, http://www.iosh.co.uk/Site-Search.aspx?terms=%22thought%20leadership%22 accessed 31 January 2014

in an appropriate manner to achieve those objectives. It does not necessarily require that those who carry out the tasks essential to achieve the objective are in agreement with the objective or are supporters of those senior to them, i.e. the necessary leader/ follower dynamic is not met.

Fundamentally, when the concept is analysed at its core lies the notion that leadership involves,

- Something/someone that others are willing to adopt or follow,
- Those who voluntarily are willing to follow,
- The surrender of the function of leadership when the above conditions no longer apply.

This latter point is often absent from the leadership discourse, though transformational leadership recognises a function of the leader as a cultivator of successors or those who would be partner leaders (Latour and Rast 2004, Reid ....). It is a necessary adjunct to the first two components and should the function of leader remain when one or both of the are removed, then leadership transforms into hierarchical authority and one of the number of forms discussed above.

Without these elements leadership as generally perceived has the potential to negate (autonomous) agency, whether of the individual or the team. Agency is central to competence (Authors, 2009a, 2009b) in as much as the competent person, constrained in his ability to take decisions within his sphere of competence and influence, becomes dependent upon others for the effective and safe outworking of his activities. Dependency is a negation of or a limitation on competence and in the sphere of occupational health and safety the decision making capacity of competent workers may be compromised by overriding decisions of safety-advisors or site managers who may be on the periphery of or outside of particular design and construction activities.

The leadership hierarchies described, whether transactional, LME or transformational in nature are all top-down approaches requiring subordinates to defer to the final decision of the supervisor or manager. There are gradations on the degree of veracity in this assessment, depending upon the industry. Thus for example in high hazard/ low risk industries such as nuclear and nuclear newbuild the level of competency required is extremely high and coming with it is the requirement that all members of the construction and industrial teams feed into the defence in depth and safety programmes to a greater extent that would be found in lower hazard industries and construction projects (Petrangelli, 2006).

Other factors influence the decision making capacity of individuals and teams, overtly it may be budgetary limitations or resource allocations set by the finance department, competency levels established by Human Resources or general and specific training deficiencies unmet by the training department. Subliminally, workplace culture, and specifically safety will be influenced to a greater or lesser degree by other messages put out by the company such as drops in profitability, fears of redundancies and so on. These messages work against safety compliance instructions and workers may well be held responsible for safety failures in which they participated (Authors, 2013).

Leadership requires an all party acceptance of and agreement to the achievement of an objective and a recognition that within the parties all are due equal consideration and respect as human beings (Kohlberg 1971). Without this latter, leadership is either a form of managerialism or a transactional relationship based go authority and wages. Eckensberger (2007) in his work on morality and culture postulates all humans as agents capable of self-reflective action. Recognising that heteronomous decision making arises out of necessities, the developing individual moves from heteronomy to autonomy and in the competent person this development has been achieved (within a particular sphere). In this perspective the competent individual or team is not led but supported and appropriately resourced by the structures within the organisation; all be it their activities are towards ends set by others. In safety, by definition it is the competent worker/ team that is the expert and by extension the safety "leader". Once set to work, the team collectively assess the requirements, including the safety requirements to achieve a successful outcome and collectively set about achieving that outcome. Team leaders may be established but in this context they act as coordinators or facilitators and are not a negation of agency within the team.

**Conclusion**

The full development of an idea or achievement of progress requires that leadership as a catalyst is relinquished in favour of the collective agency of a mature reasoning body. From an ethical perspective all human action must of necessity be based on a duty to afford no harm to others (Eckensberger 2007); in Kantian terms a particular course of right action is objectively necessary and each individual must exercise autonomy in his decisions (Kant 1785). The highest level of ethical reasoning described by Kohlberg (1971) is that in which individuals have matured from heteronomous to autonomous decision making and guided by the concept of universal consideration and respect.

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# Shale gas extraction – the case for a multi-disciplinary study

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**Shale gas extraction (SGE) and, more precisely, hydraulic fracturing, also known as fracking, has a propensity to court controversy wherever it is proposed. Many processes within SGE are essentially civil engineering processes and while numerous studies into the efficacy of SGE exist, answers to ethical and societal questions relating to safety, health and environmental sustainability remain unanswered. Recently, the UK Department of Energy and Climate Change announced its intention to support studies that encourage the development of innovative technologies for safe and responsible exploitation of the UK's shale gas resources. This paper explores the current state of knowledge regarding safety, health and wellbeing in the SGE industry, and presents the case for a detailed multi-disciplinary value-engineering study to develop pre-drill assessments and to provide ongoing monitoring tools that will assure public authorities, market operators and citizens that best-practice environmental, safety and sustainability approaches are available and feasible.**

## 1. Shale gas and the hydraulic fracturing process

The oil and gas extraction and production industry has a long history, stretching back over a century. Conventional oil and gas extraction and production is so termed because it involves drilling down to where the deposits are situated; once penetrated, the gas or the oil flows up the well to the surface. Gas and oil trapped in the impermeable shale deposits, although essentially having the same product, require a more complex process to release them. Hydraulic fracturing (HF) of the shale to extract oil and gas is one of the industry's many processes. HF, also known as 'fracking', refers to the process of fracturing the layers of oil- and gas-bearing shale hydraulically, using liquids at high pressure, to allow their trapped fluids to be released into specially constructed collection wells. Developed around 60 years ago in North America (King, 2012), and finding a fresh surge in recent times, HF for shale gas extraction (SGE) is now also practised in Europe and Asia.

When exploration establishes the presence of commercially exploitable SGE, it follows through a number of phases (DECC, 2013).

### 1.1 Drilling and completions

A well is drilled vertically down to the shale play (at depths upwards of 1–2 miles). The well borehole is continued horizontally for up to 2 miles into the shale. Several horizontal boreholes can be drilled from a single well pad. The well borehole is lined with a series of concentric metal casings that are cement sealed to avoid contamination of the surrounding ground and groundwater.

### 1.2 Hydraulic fracturing

Gas flow lines are created in the shale though a process of HF, where a fluid mix (sand, water and a 1–2% proportion of chemicals) is injected at high pressure down the well creating a fracture in the shale. The sand is used to prop the fractures open to facilitate gas flow.

### 1.3 Production

The released gas flows up the well to the surface for processing and distribution.

Drilling and completions, and the HF process, ordinarily last for a few months. This is effectively the civil engineering/construction aspect of gas recovery. The production process can then last for several years, depending on the quantity and quality of the reserves. Typically, well pads comprise 6–8 wells but can contain up to 16 (Mohajan, 2012) and possibly as many as 24 wells (Kibble *et al.*, 2013) covering an area between 1·5 and 3 ha (1 ha = 10 000 m$^2$). Composite Energy (now Dart Energy) estimates that well pad spacing in the UK will be between 1 and 1·5 well pads per km$^2$ (cited by Wood *et al.* (2011)). In the USA, Marcellus basin spacing is 3·5 per km$^2$ (Mohajan, 2012). Multi-well pads contain storage facilities and pits for flow-back fluids (estimated between 15 and 80% of fluid injected into the well (Mohajan, 2012)), equipment for drilling and processing, and flow-back recycling facilities; 80% of flow-back is capable of being recycled using current technologies (Mohajan, 2012).

At each stage of the fracturing process, each well requires between 1100 $m^3$ and 2200 $m^3$ of water, amounting to 9000–29 000 $m^3$ in total, of which 180–580 $m^3$ is the chemical additives necessary for different aspects of the process. A six-well pad will require between 54 000 $m^3$ and 174 000 $m^3$ of water and 1000–35 000 $m^3$ of chemical additives (Wood *et al.*, 2011). A 3 m deep storage pit with a volume capacity of 2900 $m^3$ has a surface area of 1000 $m^2$ and in a six-well pad 7900–138 000 $m^2$ will be required for a single HF operation, with 160–2700 $m^3$ being fracking chemicals and contaminants (Mohajan, 2012). The wide difference between the low and high is accounted for by the difference in depths and horizontal distances at different extraction sites. There are approximately 600 different chemicals used in the HF and extraction process (Kibble *et al.*, 2014) of which almost 30 are known to cause or be contributors to cancer (Colburn *et al.*, 2011). Flow-back fluids are themselves contaminated by salts absorbed from the rocks they have passed through; an estimated 20% of this is not recyclable (Mohajan, 2012). HF requires substantial quantities of high-specification sand with approximately 1800 tons per well being needed (Kibble *et al.*, 2013). In the USA, the industry demand for 'frack sand' increased from 10 million tons in 2009 to 33 million tons in 2013 (King, 2014). The high specification means that the sand has to be obtained from geological deposits of high-purity silica – that is, sand that is up to 99% silica. In a study carried out by the National Institute for Occupational Safety and Health (NIOSH, 2012), seven primary sources of airborne silica exposure were identified during HF operations, of which 47% were greater than the Operational Safety and Health Administration's permissible exposure limit (PEL) and 9% were more than ten times greater. The USA's PEL and the UK's workplace exposure unit (WEL) are both at 0·1 mg/$m^3$ for pure quartz silica, a figure that is substantially below the exposure level for amorphous silica at 6 mg/$m^3$.

New York State (cited by Wood *et al.* (2011)) estimates between 4300 and 6600 truck visits per well pad, of which 90% are associated with the HF operation itself. The calculation of the road mileage covered is complicated by a range of factors that include the distance from sand quarries, chemical production facilities, and drilling equipment manufacturers and distributors. The UK Department of Energy and Climate Change (DECC) commissioned a strategic environment assessment (SEA) on proposals for further onshore oil and gas licences in Great Britain (DECC, 2013). The assessment, also cited by Kibble *et al.* (2013), made a number of assumptions based on high and low activity scenarios

- between 50 and 150 licenses issued
- between 30 and 120 well pads constructed with
  - six to 24 wells per pad and
  - covering 3 ha
- peak number of wells drilled per year, 360
- maximum number of wells drilled, 2880 (producing 85·6 million $m^3$)
- 20 years lifetime per well.

Table 1 estimates the volume of materials required, and truck journeys and land used for SGE in the UK, based on the SEA assumptions.

## 2. SGE – the issues

The extraction of natural gas from shale formations is one of the fastest growing trends in US on-shore domestic oil and gas production (Ground Water Protection Council, cited by Jackson *et al.* (2011)). USEIA (2011) estimates that there are 750 trillion cubic feet (tcf) of technically recoverable shale gas resources in three regions of USA: the North East, the Gulf Coast and the South West. These current figures (2011) greatly expand previous estimates where it was reported (Moss, 2008) that 31 tcf might be recoverable from the Marcellus formation in the North East region of USA, compared with INTEK's estimate or 410 tcf (cited by USEIA (2011)). A recent study conducted for the Institute of Directors (Taylor, 2013) suggests that the UK could have as much as 309 tcf of shale gas in place (resources), which at a conservative estimate would be technically and economically recoverable at a rate of 10%, giving the UK potentially 30·9 tcf of usable shale gas (reserves). These figures are greatly increased in a British Geological Survey (BGS) study (Andrews, 2013) where in the Bowland Shale play (North of England) reserves estimates are set at 1300 tcf. An EU-wide study (Mathis *et al.*, 2014) estimates that member states in totality have recoverable shale gas in the order of 805 tcf. The Institution of Civil Engineers (ICE) holds the view that while there are still many uncertainties over the role that shale gas can play (in energy security), '…shale gas represents a promising additional source of energy that should be further investigated within an enhanced regulatory framework' (ICE, 2012).

A BGS report (BGS, 2011) for UK's DECC focused primarily on potential seismological activity, recommending stricter controls and procedures for developers extracting shale gas in the UK; however, there are other equally pressing environmental, public safety and health matters that need to be addressed. The recent growth in the practice of SGE has brought environmental, public safety and health concerns to the fore. As the potential for SGE expands across Europe, the European Commission and each member state (EC, 2014a) need assurances

- of the environmental integrity of extraction of unconventional hydrocarbons, such as shale gas

| | 30 well pads | | 120 well pads | |
|---|---|---|---|---|
| | Min. 180 wells | Max. 720 wells | Min. 720 wells | Max. 2880 wells |
| | Well pad area requirements: $m^2$ | | | |
| 3 ha per six wells | 22·5–90 | 90–360 | 90–360 | 360–1440 |
| 30 000 $m^2$per six wells | 0·675–2·7 million | 2·7–10·8 million | 2·7–10·8 million | 10·8–43·2 million |
| | Water and chemical requirements: $m^3$/well | | | |
| Water 9000–29 000 | 1·62–5·22 million | 6·48–20·88 million | 6·48–20·88 million | 25·92–83·52 million |
| Chemicals 180–580 | 32 400–104 400 | 129 600–417 600 | 129 600–417 600 | 518 400–1 670 400 |
| | Frac fluid storage capacity per six wells (surface area): $m^2$ | | | |
| 7900–138 000 $m^2$ | 237 000–4 140 000 | 948 000–16 560 000 | 948 000–16 560 000 | 3·792–66·24 million |
| | Sand; 1800 tons per well | | | |
| | 324 000 | 1 296 000 | 1 296 000 | 5 184 000 |
| | Truck visits | | | |
| 4300–6600 per six wells | 129 000–198 000 | 516 000–792 000 | 516 000–792 000 | 2·352–3·168 million |

**Table 1.** Estimates of materials, storage and transport requirements for HF operations in Great Britain based on DECC SEA assumptions and empirical data obtained from USA operations as presented in the Mohajan (2012) study

- that risks that may arise from individual projects and cumulative developments are managed adequately in member states wishing to explore or exploit shale gas resources.

The Commission responded to member states' calls for action by adopting recommendation 2014/70/EU (EC, 2014a) in an effort to contribute to bringing clarity and predictability to public authorities, market operators and citizens. The Horizon 2020 Energy Work Programme (EC, 2014b) states that '…in the delivery of secure, clean and efficient energy low carbon technologies it is important to develop and bring to market affordable, cost-effective and resource-efficient technological solutions in a sustainable way…'. As such it appears that in an EU context some of the most immediate SGE issues that need to be addressed are the associated environmental concerns, in particular through

- developing a better understanding of the fracturing process and its environmental effects
- advancing the treatment and recycling of flow-back and produced water
- mitigation of induced seismicity and emissions to air.

While the EU has an overarching role to play in regulation, the actual decisions are made in planning terms at member state level. The onus therefore is on each public authority to put a framework in place that will ensure that, should SGE proceed, it is properly regulated to ensure a safe and sustainable future. The framework, designed to minimise the environmental footprint, based on a sound knowledge base and scientific recommendations, will need to address short-term environmental risks, such as water contamination, induced seismicity and air pollution, and the longer-term risks, including wastewater disposal, depletion-induced subsidence or injection-based heave. Given the EU Sustainable Development Strategy's strong emphasis on social and territorial cohesion and environmental protection (EU, 2006), and the EU directive on protection of workers' safety and health (EC, 1989), it would seem logical that all are deemed integral to assessment of the environmental impacts of SGE.

In the UK, the Health and Safety Executive has regulatory responsibility for well design and construction and, among other things, it requires independent verification of the well design and a detailed examination of its integrity during construction and operation. Additional scrutiny is afforded through the planning process, where the Environment Agency has responsibility to consider both the strategic and the environmental impact of any proposed SGE operation.

## 3. SGE – the challenge

McAleenan *et al.* (2013), citing Lechtenbohmer *et al.* (2011), who in a report to the European Parliament advocated the need for a reassessment of the full impacts of SGE, concluded that there was a wide range of conceivable accident risks such as 'blow out with frack-water spills, leakages from wastewater or from fracture fluid ponds or pipes, groundwater contamination due to improper handling or unprofessional cementing of the well casing'. Lechtenbohmer *et al.* (2011) argue that the realisation of these could well be due to inconvenient handling, increasing economic pressures resulting in a speeding up of the process, which has the potential to decrease due diligence in hazards control with a consequent increase in the frequency of accidents. However, they believe that these risks can be reduced and probably avoided with adequate technical directives, cautious handling practice and supervision by public authorities. Ewen *et al.* (2012), in contemplating the future for SGE, concluded that there was no need for an outright ban on the practice of HF, acknowledging that until now several unknowns exist with regard to the environmental and health impact of the process. They suggested proceeding with caution, not whole scale, indicating that 'a defined state of the art; a legal framework that addresses the new risk dimension entailed by hydrofracking [sic]; and additional scientific knowledge' is necessary if the process is to proceed. McAleenan *et al.* (2013) advise that an element of realism exists, which recognises that gas extraction is going to be part of the immediate future but that it should not be carried out in isolation from other human activities and needs in respect of the environment. Rather, it must be fully integrated within national biodiversity and social protection measures. Where harm, real and alleged, has occurred, independent, objective assessments are required that will determine the nature of the harm, its causes and what will be required to remedy the situation and prevent reoccurrences. Should environmental impact assessment processes and continual sustainable monitoring regimes become an accepted industry standard guidance within EU, and the member states implement the guidance within their regulatory framework, that will go a long way in ensuring that it gains social acceptance. Consequently, the industry can move forward in a socially responsible manner, providing that concerns of the citizens regarding their health, safety and wellbeing can be allayed.

## 4. SGE – safety, health and wellbeing – what we know

There are many hazards in the SGE industry of which the degree of exposure and the extent of appropriate controls still have to be tackled. The global growth of the SGE industry has raised safety, health and environmental concerns and yet, while much has been written and spoken about the scientific and technical aspects of SGE, issues such as workplace safety and health still lack the critical examination that is required if the discussion, and ultimately any final choices, are to be appropriately informed. As the SGE debate progresses, the decision as to whether it should continue, or even expand, research into the ability to control worker safety and health by engineering controls and through managerial procedures has to take a higher priority in order that final choices are appropriately informed. Cleary (2012) referred to the many unknowns to date, focusing specifically on citizens' health and wellbeing and pointing to the fact that often public health agencies are late getting involved with initiatives regarding regulating industries such as SGE. Consequently, medical health, public health and environmental health tend to either have a 'back seat' or 'miss the bus altogether'. Kibble *et al.* (2013), in a report for Public Health England, noted that the findings relating to health impacts within the SGE process were inconclusive and likely to vary depending on the scale of operations. The recommendations of the report include the need for more public health studies and monitoring of any future 'roll-out' of SGE across the UK. In USA reviews of occupational safety and health hazards associated with HF, health, and in particular worker exposure to respirable crystalline silica, was the dominant hazard discussed (NIOSH, 2010). Not being fully aware of the extent of, location of and rate of development makes it more difficult to predict the size of the challenge facing the community. How many increased traffic movements are necessary to service the HF process and will this naturally lead to increased traffic collisions? What volume of water, sand and associated chemicals are needed, and how does this impact on environmental and citizens' health?

Maybe the question to be raised is what is known about public health, workers' safety and health impacts stemming from conventional oil and gas development and how does that compare with the unconventional SGE. The research methods employed to date have been largely exploratory, focusing on current literature and interviews with key players in SGE industry and associated fields. More is needed. The work going forward has to engage with regulators, affected communities and SGE operating companies to define adequately the nature of safety-, health- and environment-related hazards in SGE, from each of their perspectives. The outcome will help lead to the identification of solutions that could be developed to offer an enhanced/improved sustainable performance within the industry.

## 5. SGE – the proposed study

Presently, there are still no definitive answers to the societal questions relating to safety, health, wellbeing or environmental sustainability. Perhaps much of that can be blamed on a high degree of confusion/scepticism promulgated within popular media and may even be on information overload. What is it that makes a person hold firm to their belief in the face of what is overwhelmingly conclusive and scientifically proven information? Is it lack of trust? Fear? Or is there a crowd mentality leading to a universality of behaviour? As the debate to determine the future for SGE continues, the adoption of a multi-disciplinary approach is needed, involving science and engineering, health and psychology, and value and safety engineering, exploring how functional aspects combine in the delivery of sustainable development through knowledge, skills and professional expertise. Individually, it is possible that SGE construction sites present no greater a series of hazards than those presented with any other construction project. However, given the scale of the operations, with the potential for extensive numbers of SGE sites being developed across Europe in the coming years, the issue could come down to repeated and frequent exposure to some hazards, together with the considerable associated volumes of material and quantities of truck movements (Table 1), which present specific concerns for safety and/or health. As with the community health issues (Cleary, 2012; Kibble *et al.*, 2013) workers exposed on a long-term basis to hazards such as respirable crystalline silica (NIOSH, 2010) and extensive transportation/traffic hazards, there remain a lot of unanswered questions. Is there a viable supply chain in place with all the necessary management controls? To what size is the industry likely to expand? While the concerns will revolve around safe design, construction, operation and, ultimately, demolition, the exact nature of the issues must first be determined if controls are to be effective at each stage of the process.

The proposed study sets out with no preconceptions about SGE; rather, it sets out with the aim of developing the tools that will allow objective decisions to be made by all concerned. This necessarily will involve all of the key stakeholders in the study and in the dissemination of deliverables. The study proposes concentrating on further developing the scientific knowledge base, focusing on both the geo-environmental and the societal aspects of the SGE industry from the conception/exploration stage, through exploitation to final completion and exit. The exit strategy has to include well abandonment in a safe and sustainable manner, taking cognisance of the potential for future redrilling, should future technologies render further extraction financially and technologically viable.

Logically, then, there is a need to study the safety, health and wellbeing of SGE operatives to determine whether they are exposed to new or unique hazards, in order to be in a position to recommend best practice control measures, based on the intervention practices of industry's best performers. The follow-up work should establish the efficacy of eliminating or mitigating safety and health hazards, using established and emerging safety management and safe design practices. Equally, complementary work is required to determine impacts on citizens' health associated with SGE (Cleary, 2012) with a holistic approach focused on the inter-related conditions and factors that influence the health of a population. The determinants of citizens' health include, among others, social, economic, biological and physical factors, and therefore the study needs to scrutinise socio-economic and psycho-social impacts, examining existing health impact models to establish what critical factors have to be addressed.

## 6. SGE – the study ambition

Successful conclusion of a project of this nature will deliver the knowledge base and scientific recommendations that will allow public authorities, market operators and citizens to make objective decisions regarding minimising the SGE environmental footprint. Building on the knowledge and experiences in the USA and Canada, the inter-related best practices documents should present an opportunity for the development of harmonised standards across all EU member states. The project also has the potential to influence EU policy in the SGE sector, tying in with the European Commission's recommendation (EC, 2014a), which calls for more clarity and predictability. While the EU has an overarching role to play in regulation, the actual decisions are made in planning terms at the member state level. The Commission has invited member states to follow minimum principles when applying or adapting their legislation applicable to hydrocarbons exploration or production using high-volume HF. The onus is on public authorities to put the framework in place, which will ensure that, if SGE is to proceed, it is properly regulated to ensure a safe and sustainable future.

Ultimately, there is a need to develop and deliver credible, unambiguous and impartial information on all facets of SGE. Should the environmental impact assessment processes and continual sustainable monitoring regime become accepted as industry standard guidance, and should member states implement the guidance within their regulatory framework, it would go a long way towards ensuring social acceptability. It will enable the SGE industry to move forward in an ethical and socially responsible way, assuming the citizens' concerns can be assuaged, greatly improving the likelihood of realising energy security across Europe.

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# CALCULATION OF THE NUMBER OF SYNERGISTIC HAZARDS AND RISKS ON CONSTRUCTION SITES THAT LIMITS THE EFFICACY OF RISK ASSESSMENT MATRICES

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Fatalities, injuries and work-related diseases continue to occur on construction sites some 40 years after the introduction of the Health and Safety at Work Act (HMG 1974). Despite the best efforts of the industry to achieve safe and healthy workplaces, improvements have reached a point where year on year change is minimal. This paper explores a practice that has emerged in the intervening years; 'Risk Management', which has an underpinning ideology that risk be reduced, so far as is reasonably practicable (SFARP), but not necessarily eliminated and makes the case that the risk assessment/risk management approach adopted in the UK has been misinterpreted and is thus a contributory factor (barrier) to the slow down in improvements. In particular it argues that the risk matrix approach leads to unnecessarily excessive risk assessments and documentation that contributes to a cycle of neglect in occupational safety and health (OSH). The paper presents for consideration the concept a mathematical limitation on the efficacy of synergistic hazard analysis.

Keywords: measurement, risk, synergies.

## INTRODUCTION

Construction sites are unquestionably hazardous environments; that they are at the same time dangerous is not necessarily an adjunct, a matter legislation accepted with the implementation of the 1974 Health and Safety at Work Act in the UK (HMG 1974) with the duty imposed on employers to ensure the safety, health and welfare of all their employees. Similar duties exist in the USA, Canada, Australia and across Europe. Their impact on construction had generally been positive with a fall in both the absolute number of fatalities and injuries and in the frequency rates (Figure 1). However, despite the best efforts of statutory authorities, the safety professions and the industry, construction sites remain both hazardous and dangerous places of work. In the UK there were 42 fatal injuries in 2014, with 592,000 days lost due to injury and 31,000 new cases of work related ill-health, adding to a total of 76,000 accounting for 1.7 million lost days, (HSE 2015)

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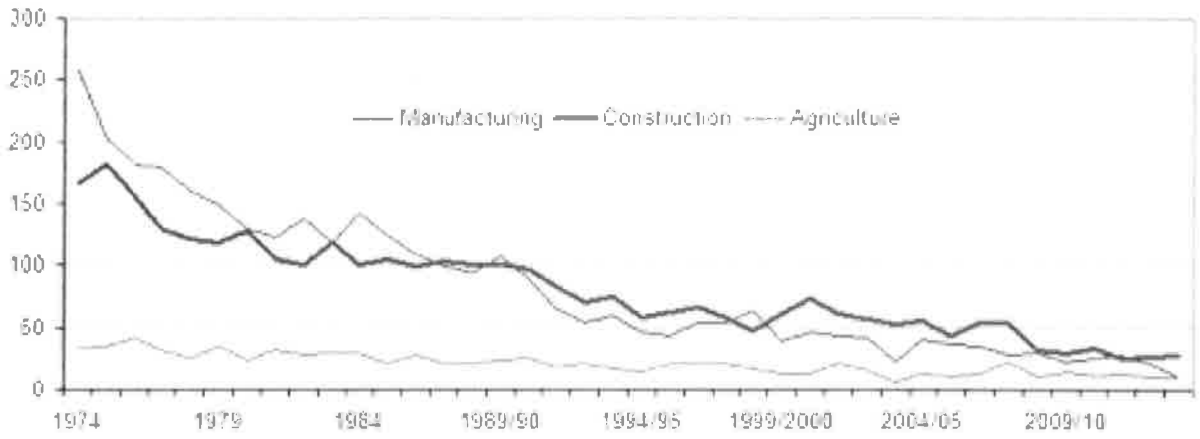


*Figure 1: Numbers of fatal injuries to employees (RIDDOR) 1974 to 2013/14*
*Source: HSE 2015*

## VISION ZERO

The capacity to achieve injury/fatality free worksites is possible and this vision is the foundation of the International Labour Organisation's (ILO) (2008) strategy for prevention and the Vision for Sustainable Prevention (ILO 2014). It has also been incorporated into UK law (Reg. 4, Management of health and safety at work regulations, 1999). But despite this acceptance, the debate on "vision zero" continues, not in terms of how it is to be achieved, but whether it is realistic or not; a desirable aim or vision but one that may not be achievable in the real world (Hughes 2011, Ormond 2014). The ILO (2014), recognising the progress made in occupational safety and health (OSH) nonetheless stated that amongst some stakeholders the attitude still exists that "*...OSH is at odds with competitive advantage and viability...*" and there is evidence in the construction industry that OSH resources and training suffer when the bottom line is at risk. In other circumstance a negative attitude towards OSH emerges from ignorance regarding the causes of accidents and disease and what can be done to prevent them, creating a cycle of apathy and less demand for addressing the issues, what the ILO terms a "*cycle of neglect*" (ILO 2014).

The factors impinging on the capacity to prevent accidents and diseases are varied; negative attitudes create negative outputs, as illustrated (Figure 1), but it does not automatically follow that positive attitudes achieve the full range of positive outputs hoped for. There is also evidence that contractors and consultants who have adopted the zero harm vision and who implement OSH management systems nonetheless remain vulnerable to having risky work environments despite their leadership, safety programmes, training and the resources that they put into safety (Allen and Clarke 2014, AngloAmerican 2014, EDF 2015).

## RISK ASSESSMENT AND RISK MANAGEMENT

Risk assessment and how much risk assessments a contractor carries out is often held up as evidence of good practice. Indeed procurement processes demand evidence of same (McAleenan 2010) as does the CDM 2007 ACoP (HSE 2007). This became problematic when it resulted in the production of voluminous written documentation addressing risk that the UK parliament established a working party to examine the causes and problems of risk assessments, (McAleenan 2008, WPC 2008). A number of issues were addressed including the misinterpretation/over interpretation of legislation, covering all bases just in case of an accident and the need to ensure documentary evidence in case an accident did occur. Löfstedt (2011) reached similar conclusions.

Whereas the UK law requires that employers assess the risks to which their employees may be exposed and put in place such measures as are necessary to comply with the principles of prevention (HMG 1974), and that such processes are managed appropriately (HSE 2013, BSI 2007, ILO 2001) a practice has emerged which is in essence Risk Management, with an underpinning ideology that risk could be reduced, so far as is reasonable practicable (SFARP), but not necessarily eliminated, particularly when the costs in time, effort and resources are grossly disproportionate and the option, with regard to risk, is to fund the loss, (RRC 2004).

A model for risk assessment emerged from the UK's Health and Safety Executive's (HSE 2013) guide to risk assessment (based on the HSG65, originally published in 1991) that included an example of how a simple risk assessment may be undertaken which suggested that employers identify the hazards and who may be harmed by them, decide upon the likelihood of the harm occurring, "i.e. the level of risk", and what to do about it. It was also suggested that employers are not "*expected to eliminate all risks...but make sure they know what to do about the main risks and the things [needed] to manage them properly*" (HSE 2013)

Risk management is a self-contradictory statement that promotes the concept of acceptable levels of risk, i.e. injury and fatality (McAleenan and McAleenan 2001). By definition, "risk" is the possibility or likelihood of harm or danger and containing within it the notion of absence of certainty from which chance determining which of two or more outcomes are likely. Management, on the other hand is the authoritative control of work activities. If there is control of an activity, chance is removed and there is only one possible outcome, that which is established at the outset. If it is not known with certainty what the outcome will be any action becomes a gamble on the outcome being what is desired.

In practice, and following on from HSG65's statement (HSE 2013) that not all risks need be eliminated, risk management posits an acceptable level of risk and becomes then an exercise in manipulating the circumstances to increase the odds in favour of non-injurious outcomes. However the legislation is not aimed with reducing the risk, i.e. increasing the odds in favour of non-injurious outcomes; it is concerned with employers managing work activities in hazardous environments such that there is no risk.

There is no specific requirement to risk manage in the legislation. Common usage of the risk management term appears to stem from loss control in the insurance industry, spreading without full due diligence into the world of workplace safety and health. ILO (2001) refers to risk assessment and the need for OSH management; perhaps the conflation of the two terms coupled with the linkage back to insurance risk has influenced the safety profession's interpretation of risk assessment resulting in the inappropriately named risk management in safety and health circles. Commencing with the objective of a safe outcome, management aims to achieve that objective, safety, not risk, is managed and if we can control the safety of an operation, it is immaterial how hazardous the environment is, the operation itself is nonhazardous, and the outcome will always be non-injurious.

In the analysis of Risk Management, described as a failed paradigm, (McAleenan and McAleenan, 2005 and 2008[68]) the approach adopted was to explore the language that framed the safety discourse and from which safety practice emerged. Ritchie and Thatchuk (2014) also explored the role of language in framing the safety discourse. Risk Assessment and Risk Management had been central to

[68] Expert Ease International organized and hosted a seminar at the ILO's 2008 World Congress on Safety and Health in Seoul entitled, "Risk Management - A Failed Paradigm".

the business and public health discourses throughout the greater part of the 20th century and is an attempt to measure the threats and uncertainties that could potentially disrupt or harm a company's business, insurances or public health in ways that are unacceptable. When it became part of the UK workplace health and safety legislation [69] the language of risk and risk management was adopted and made fit for the circumstances of the worksite, thus concepts such as acceptable risk and tolerable risk, which had a place in the insurance industry, entered the lexicon of the safety profession and were applied to the acceptability or tolerability of accidents and injuries. Missing from the discourse is the question of whether such concepts were appropriately transferable from financial risk to human workplace safety risk. In one sphere the risk was to a consolidated resource (finance) that should a non-catastrophic percentage be lost the remainder of the resource could be sufficient to regenerate the loss; thus an acceptable or tolerable risk. In regard to the workplace, the resource (an unfortunate and dehumanising terminology) is human beings and is not so conglomerated, and the loss of any percentage through injury or fatality could not be regenerated by the remainder. Thus acceptable risk as applied to the firm's financial risk could only go against rationality and morality when the same concept was applied to people. Yet it persisted, sometimes rationalised to mean acceptance of smaller injuries and "near misses". Indeed it was the perception and use of labour as a replenishable resource that led to the horrific conditions that characterised much of 19th industrial work, (Clarke 1908) and which led the legislative base founded on the principles of duty of care and strict liability of the employer for the health and safety of those they engage in their undertakings.

## RISK MATRICES, SYNERGISTIC HAZARDS AND RISKS

If Risk Assessment is the attempt to measure the threat of hazards to workplace operations based on identified assumptions and uncertainties, Risk Management is the attempt to manage the work operations in the face of those uncertainties. In engineering practice this process has value when utilised at the design stage, allowing for the development of design improvements and safeguards before being transferred to the contractor for realisation. However, on the construction site the application of Risk Management to human working practices raises epistemological issues with the understanding of "risk". Risk is the likelihood of an event occurring and thus is a concept associated with probability. The assessment of risk is an assessment of probability and the probability of an event being realised lies between 0 and 1. In management terms a controlled event has a zero (0) likelihood of occurring whereas when the likelihood is $> 0$ and $\leq 1$ the event is uncontrolled to an extent commensurate with the likelihood. The process of assessment, even with the most accurate of assumptions and statements about uncertainty cannot with a sufficient degree of certitude determine when the event will be realised. The Risk Assessment process is non-predictive and thus to accept the probability of an event occurring - however unlikely - is to accept the possibility that it will occur at any time. Risk Management can reduce the likelihood but cannot change the unpredictability inherent in the uncontrolled real world events on-site.

Maharaj (2012) has described synergistic hazards as those involving the interaction of the hazards presented by people, the environment in which the work takes place and the tasks being undertaken, (the PET model). The number of hazards that can exist on a construction site is large, for example in Maharaj et al (2012) 40 types of hazard have been categorised. When used in conjunction with the number of workers on site, the number of synergistic hazards to be assessed can rise exponentially.

A standard risk matrix, used not infrequently by the safety profession, and included in core health and safety training programmes utilises a simple likelihood of an event occurring x severity of outcome

[69] The Health and Safety at Work Act 1974 made it a duty not to expose workers to risk to their health and well-being and the Management of Health and Safety at Work Regulations 1999 made it a duty to carry out an assessment of the risks

matrix with a scale normally from 1 - 5 for each component. This gives a 5 x 5 = 25 possible outcomes that are classified as

- Red - requiring immediate action before proceeding
- Amber - requiring some action but can pro ceed with administrative controls,
- Green - can continue but may require further actions

However this matrix fails in that it does not take into account the possibility of multiple non-fatal injuries per worker in any given accident. Using the formula developed by Hand (2014a)

$$2^N - 1$$

where N = the sum of the elements (i.e. possible combinations) in the set, we find that

$$2^4 - 1 = 15$$

possible non-fatal injurious outcomes at each level of likelihood or 15 x 5 = 75 possibilities in addition to fatal outcomes.

When workers are introduced to the matrix the number of possible outcomes increases substantially such that with 5 workers on the site the matrix would have an extra dimension. However the calculation is not 5 x 5 x 5 = 75 but, using Hand's formula and

$N_w$ = the set to be combinations of workers who could be injured, and

$N_o$ = the set of different levels of injury (outcomes) (excluding fatality[70]) that could be sustained, then,

$$(2^{N_w} - 1)(2^{N_o} - 1) = (2^5 - 1)(2^4 - 1) = 31 \text{ x } 15 = 465 \text{ possible injurious subsets.}$$

When we consider that this is the risk presented by a single hazard, multiple hazards ($N_h$) with the potential to interact with each other produces a calculation of subsets substantially greater. For example, the same 5 workers exposed to 5 hazards with potentially 4 levels of injury (excluding fatality) produces the following:

$$(2^{N_w} - 1)(2^{N_h} - 1)(2^{N_o} - 1) =$$

$$(2^5 - 1)(2^5 - 1)(2^4 - 1) =$$

$$31 \text{ x } 31 \text{ x } 15 = 14{,}415 \text{ possible injurious outcomes}$$

Synergistically on a site with 40 types of hazards and 100 workers there are (using the same calculation for subsets):

$$(2^{N_w} - 1)(2^{N_h} - 1) =$$

$$(2^{100} - 1)(2^{40} - 1) =$$

$$(1.268\ldots \text{ x } 10^{30})(1.099\ldots\text{x } 10^{12}) =$$

$$1.393\ldots\text{x } 10^{42} \text{ subsets or synergistic hazards.}$$

[70] Fatal incidents are excluded from the calculation for simplicity. An accident that injures a worker may leave him with several different injuries from minor to severe, all of which need to be treated. However in the case of a fatal accident it adds nothing to the process to calculate what other injuries the deceased may potentially suffer.

This is a truly phenomenal figure of synergistic hazards and all have the potential for the same 4 levels of (non-fatal) injury. Thus there are potentially,

$$(1.393...\text{x } 10^{42}) \text{ x } 15 =$$

$$2.091...\text{x } 10^{43} \text{ subsets of non-fatal injury combinations.}$$

Combined with the potential for fatalities, (100 in this example, there being 100 workers) these are the set of all negative outcomes. There remains to consider that there is another subset to complete the list, namely the positive desired outcome, again 100, being the number of workers on site. Hand's (2014b) Law of Inevitability states that one of the complete set of all possible outcomes of a random event must occur, no matter how improbable or unlikely. Large scale multiple fatalities are low probability events but the following examples (Table 1) illustrate the Law of Inevitability and that they do happen.

*Table 1: Large scale multiple fatality/injury incidents*

| Incident | Fatalities | Injuries/illness | Reference |
|---|---|---|---|
| Bhopal, gas release | >25,000 Mostly public | >120,000 Mostly public | http://bhopal.org |
| Piper Alpha, explosion | 167 | - | https://gcaptain.com/piper-alpha-disaster-19-year-anniversary-of-tragedy/ |
| Pemex, explosion | 500-600 | 5,000 - 7,000 Mostly public | http://www.hse.gov.uk/comah/sragtech/casepemex84.htm |
| Chernobyl, radiation exposure | 30 (+19 not fully attributed to radiation) | 134 | http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Chernobyl-Accident/ |
| Rana Plaza, Bangladesh Structural failure | 1,134 | ≅2,500 | www.ranaplaza-arrangement.org |

# CONCLUSION

The risk management/ risk assessment approach has had some positive benefit in improving OSH on construction sites, particularly when used sensibly and with the thought that it is a tool for achieving worker safety. However ideologies have developed around the requirement to assess risk that have transformed it into a process that achieves voluminous amounts of paper work that are inaccessible to those for whom they are meant and which serve to create a barrier to the achievement of safe practices by opening up OSH to ridicule. The process of risk assessment that has been developed on the back of this perception of what is legally required cannot realistically achieve what it aims to do because of the truly vast numbers of synergies generated, but nonetheless has succeeded in generating substantial amounts of unnecessary paperwork. The achievement of a culture of prevention and continuous improvement requires the re-imagining of the legislative requirements and a jettisoning of the incorrect risk management approach, in favour of managing the activity itself such that it has a favourable outcome at all times.

Hazards exist, often discretely, but in the interaction between the worker when on site, the tasks being conducted and those hazards, new synergistic hazards emerge with increasing degrees of complexity as multiple hazards, workers and activities merge in the developing project. These synergies mean that the hazard cannot be eliminated, they must be controlled in a manner commensurate with the nature of the hazards and the degree of complexity. The mathematics herein illustrates how many synergistic hazards there may be on a construction site, but more importantly it illustrates how ineffectual the traditional risk assessment and risk matrix approach is in accounting for, describing and identifying all the controls for all the synergies. The core requirement is to provide a safe and healthy work environment. Risk assessment is one of many tools to assist in achieving this and the degree to which it is to be used is to be determined by its effectiveness in achieving that core objective, and it is not to be used beyond its rational limits.

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# REVISITING LORENT

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Much of the archival design related accident causality research in the construction industry points to a 1987 National Action Committee for Occupational Safety and Health in Construction (CNAC) report. This research analyses the CNAC report and follow other research documents that have referenced the report with a critical evaluation. The original 1987 report focuses on design's influence on falls from height rather than all of the hazards present on construction sites. Yet, in that report it is confusing as to the exact nature of the recommendations, and as a result, may have inadvertently affected the pursuit and direction of subsequent research. Our research examines the potential discrepancy and its impact on accident causality research in the construction sector. The importance of finding and reading primary source material in construction research is highlighted. A potential concern is that the unreasonable attribution of design in accident causality causes the industry to lessen the focus on safe design overall; thus, those areas where safe design could truly have a positive impact (i.e., falls from height) get overlooked and under-emphasized.

Keywords: construction, design, falls, prevention though design, safety.

## INTRODUCTION

The concept of Prevention through Design (PtD) aims to integrate hazard analysis and risk assessment methods upstream from the construction site, during the conception and design phases of a project in order to take the necessary actions to reduce the risks of injuries and damages to an acceptable level (Manuele 2008). The need for this early consideration of safety hails from the hierarchy of controls. The hierarchy of controls is an orderly and systematic ranking of safety measures into broad

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categories. These categories according to Manuele (2009) are: 1) Elimination, 2) Substitution, 3) Engineering Controls, 4) Warning Systems, 5) Administrative Controls, and 6) Personal Protective Equipment. Controls that are higher in the ranking, such as Elimination, Substitution and Engineering Controls, have greater effectiveness and financial value compared to controls lower in rank, but require input from designers, as well as input during planning, in order to implement them on a construction project (Manuele 2009).

By the same token, inaction and inability during design and planning, are seen as influences for accident causation. One of the first authors to make this suggestion was Pierre Lorent in a report that he prepared for the Belgian National Action Committee for Safety and Health in Construction (Comité National d'Action pour la sécurité et l'hygiène dans la construction) the leading agency for construction safety and health in Belgium (Lorent 1987). The report, which was written in French, was instrumental and influential in generating interest in PtD in Europe. However, as discussed within this paper, the original report requires additional review and consideration.

# BACKGROUND ON THE 1987 LORENT REPORT

Within his report, Lorent (1987) attempted to link quality management solutions to solutions for the improvement of construction safety. The forty page report dedicates only three pages to safety (Section 7), while at the same time several subsections of Section 7 include the statement "Etude en cours" (work in progress). At the time, "work in progress" was specified for the following subsections of the report:

- 7.2 Classification des accidents de travail dans la construction (Classification of work accidents in construction)
- 7.3 Categories d'accidents en hausse (Categories of accidents on the rise)
- 7.4 Types de travaux où se produisent des accidents graves (Types of work where serious accidents occur)
- 7.7 Relations entre les risques d'accidents de travail, conditions de travail et productivité (Relationships between the risks of work accidents, working conditions, and productivity)

Sections 7.4 and 7.5 of the report are shown in Figure 3 in French, and in English in Figure 4. Section 7.4 is titled "Analysis of the causes of accidents from falls from height" and discusses the "severity of the accidents", stating that 35% of fatal accidents are caused by falls from height. In addition, Section 7.4 indicates that for every 100 fall fatalities, 31% occur from scaffolding/formwork, 18% from roofs/ glass canopies, and 12% during finishing work. The section continues with the categories of workers who are most often injured from falls from height. The percentages are as follows: 25% of the workers are form setters/ ironworkers/ concrete workers, 22% of the injured do finishing tasks, and 11% of them do civil engineering work. Finally, as mentioned previously, the section regarding the types of work where serious accidents occur was still a work in progress.

What is important to note for Section 7.4 is that all of the figures stated are not referenced to previous research or recorded data, and Lorent does not provide a source for these numbers. Furthermore, within Section 7, which is devoted to safety, he only discusses accidents involving falls from height.

7.4. Analyse des causes des accidents suite à une chute de hauteur

- Gravité des accidents : 35 % des accidents mortels

  sur 100 accidents mortels par chutes

  31 % échafaudage - coffrage (conception du matériel et organisation)

  18 % toitures, verrières... (conception architecturale)

  12 % travaux de second oeuvre

- catégories de travailleurs accidentés suite aux chutes de hauteur

  25 % coffreurs, ferrailleurs, betonneurs (conception du matériel)

  22 % second oeuvre (organisation des co-activités)

  51 % génie civil

- types de travaux où se produisent des accidents graves (plus d'3 mois d'incapacité)

  étude en cours

7.5. Impact de la conception et de l'organisation, en amont du chantier

- Objectif : diminution du nombre des chutes de hauteur 30%
  : diminution de la gravité des accidents suite aux chutes de hauteur : 40 %

- Les actions positives se situent au niveau d'anticipation le plus élevé
- La diminution du taux de fréquence des chutes de hauteur est entravée par une augmentation de l'exposition aux risques (voir augmentation de la productivité des travailleurs page 3, tableau n° 2)
- une évolution technique dynamique qui ne tient pas assez compte de la sécurité au travail.

*Figure 3-Extract from the Original Lorent Report (Lorent 1987)*

In Section 7.5, Lorent proceeds to discuss the impact of design and organization upstream from the work site. He states the objective to be the reduction of the number of falls from heights by 30%, and the reduction of the severity of the accidents from falls from height by 40%. The impact is summarized by three bullet points that are shown in Figure 3 (French) and Figure 4 (English).

It is unclear how the data described above was collected and how causal attributions are made. The percentages are allocated against various aspects of work: scaffolding, roofs, glass, etc. It appears that these are attributed to design activities. For example roof glass is associated with architectural design while scaffolding is linked with design of material and organization. Similarly, categories of injured workers are linked with design activities. It is not clear that this linking is defensible as the full evidence for the relationships implied between design activity and the severity and categories of injured workers was not established in Lorent's report.

7.4. Analysis of the causes of accidents from falls from height

- Severity of accidents: 35% of fatal accidents

  For every 100 fatalities from falls

  31% scaffolding - formwork (material design and organization)
  18% roofs, glass canopies ... (architectural design)
  12% work on finishing work

- Categories of injured workers following falls from height

  25% form setters, iron workers, concrete workers (equipment design)
  22% finishing work (co-organization activities)
  11% civil engineering

- Types of work where serious accidents occur (over 1 month of incapacity)

  Work in progress

7.5. Impact of design and organization, upstream of the work site

- Objective : Reduce of the number of falls from height by 30%
  : Reduce the severity of accidents following falls from height: 40%

- Positive actions are at the highest level of anticipation
- The decrease in the frequency rate of falls from height is hindered by increased exposure to risk (see increase in worker productivity page 3, table No. 2)
- A dynamic technical development which does not take sufficient importance in work safety

*Figure 4-Translation of extract from the Original Lorent Report, in English*

## BACKGROUND ON THE 1991 REPORT BY EUROFOUND

The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a European Union Agency that aims to disseminate information, advice, and expertise on matters relating to living and working conditions in Europe. It is based both in Dublin and Brussels, and has produced several publications on topics ranging from working conditions and labor relations, to social policies (Eurofound 2015).

In 1991, Eurofound tasked Lorent to assemble a booklet of six national studies carried out for Eurofound (Eurofound 1991), that included his own 1987 study "Comité National d'Action pour la Sécurité et l'Hygiène dans la Construction, P. Lorent, Les conditions de travail dans l'industrie de la construction Productivité", and the following five studies:

- The Management College, Birchall, Working in the Construction Industry, Henley, March 1987.

- CERTES, Campagnac and Caro, Les conditions de travail dans l'industrie de la construction, Paris, March 1987.
- Stichting Bouwresearch, Diepeveen and Brouwers, Les conditions de travail dans l'industrie de la construction, Rotterdam, March 1987.
- RSO, Rollier, La sicurezza nel settore delle costruzioni come problema di organizzazione e di progettazione, Milan, February 1987.
- Projektgruppe Arbeitsbedingungen in der Bauwirtschaft (PAB), Spannhake, Les carences de la sécurité du travail dans l'industrie de la construction et les frais qui en découlent, Dortmund, March 1987 (Eurofound 1991).

Chapter 2 of the booklet addresses the hidden costs associated with construction, and among these costs, Lorent mentions the costs of occupational accidents (Section 2.2). In addition to costs, Lorent discusses the causes of accidents (Section 2.2.3), where in reference to his 1987 report, he states that *"... an analysis of fatal accidents on building sites tends to show that about two thirds of them are due to shortcomings in design (architectural choices, decisions on materials and equipment, and organizational problems. ... "*, a statement that is never made in the 1987 report (Eurofound 1991).

In continuation, Lorent states that 35% of fatal work accidents are caused by falls, and assumes that all falls are caused by design, 25% (shown as 28% in the figure in the report) (Haslam et al. 2005)have organizational deficiencies, and 37% are caused by implementation issues. It is clear from these numbers that there seems to be some discrepancy. Falls can be caused by both organizational deficiencies and by implementation issues. In addition with the exception of the 35% for falls, the other two percentages are not shown in the original 1987 report. Thus the statement that *"... about two thirds of them (fatal accidents) are due to shortcomings in design decisions and organizational problems ... "* does not seem to be justified. Furthermore, no source of the information presented is mentioned (Lorent 1987; Eurofound 1991).

Lorent concludes this section of the report with a table repeating the data from his 1987 report, under Section 7.4 "Severity of Accidents" shown in Figure 4. He concludes *"... that about 60% of fatal accidents on building sites arise from decisions made upstream of the site... "* Again there seems to be a discrepancy since the original report does not mention methods for prevention for these accidents, nor any discussion of how the conclusion was reached. In this case Lorent states that "Scaffolding/ shuttering" accidents are prevented by "Equipment design and organization", "Roofing, facades, glazing, maintenance" are prevented by "Architectural design", and "Finishing works" are prevented by "Organization" (Lorent 1987; Eurofound 1991).

The value of 60% seems to be very high since more recent research has revealed a range from 27% (Haslam et al. 2005) to 42% (Behm 2005). Another issue that needs to be addressed and it is not mentioned in the report, is how far upstream should safety be considered; planning/design of the construction process at the beginning of the construction work, or to the design of the structure prior to the start of construction.

The Eurofound report makes more explicit statements about causality than the original Lorent report. Though questions arise as to the way fatal accidents were analysed and causal attributions were made. The statement that two thirds are due to shortcomings in design and organisational problems is problematic. The authors would argue, however, that sub-optimal design decisions are often made due to organisational problems, i.e, not consulting the right people at the right times and not following robust OSH risk management processes.

Organisational problems are also cited as consequences arising from the combined activity by members of different trades. In fact upstream organisational issues giving rise to sub-optimal H&S outcomes might involve a much broader range of scenarios than this. The coordination of multiple trades is arguably a site-based operational issue associated with the coordination of work in the construction stage of a project. The question of whether this should, in fact, be classed as an upstream activity arises.

Again, providing the causal analysis and methods used for attribution would help to clarify how the EU Foundation figures were derived. Again, like Lorent, there seems to be a lack of conceptual clarity in the interpretation of causes.

# IMPACT OF THE EUROFOUND REPORT

Since the Eurofound report was published, several other publications have referenced the statements made by Lorent. In one example in conference proceedings, Jeffrey and Douglas (1994) refer to the Eurofound report as research carried out by Eurofound, and cite Lorent's conclusions as follows:

- *"60% of site fatalities can be related to decisions made off-site*
- *35% of site fatalities were caused by falls which could have been reduced through design*
- *25% of site fatalities are due to the simultaneous performance of incompatible activities*
- *37% of site fatalities are due to the management of production"* (Jeffrey et al. 1994)

In another example by Churcher and Alwani-Starr (1996), in conference proceedings again, the authors reference the Eurofound report showing and erroneously referring to the percentages of accidents attributed to project stages as 36% for Design, 36% Construction, and 27% Planning. These numbers in the Eurofound report as mentioned before are 35% for Design, 37% for Implementation (Construction), and 28% for Planning (Organization).

As expected this secondary and tertiary referencing created a cascading effect where newer publications utilized references in other publications without checking the original source documents. Such an example is observed in the Australian CHAIR Safety in Design Tool (NSW Workcover 2001), which references the Churcher and Alwani-Starr (1996) proceedings and their reference of the Eurofound report as research performed by them.

## Did the Lorent and Eurofound reports lead to legislation?

Furthermore, it is possible that the Lorent and Eurofound reports were motivating factors for the development of extensive legislation, at least in Europe. As observed within the language in the Council Directive 92/57/EEC (EEC 1992) on the implementation of minimum safety and health requirements at temporary or mobile constructions sites, although the preamble does not cite the reports, there are several statements in the preamble that seem to repeat statements made by Lorent. Such examples are the following:

*"Whereas unsatisfactory architectural and/or organizational options or poor planning of the works at the project preparation stage have played a role in more than half of the occupational accidents occurring on construction sites in the Community"*

*"Whereas, when a project is being carried out, a large number of occupational accidents may be caused by inadequate coordination, particularly where various undertakings work simultaneously or in succession at the same temporary or mobile construction site"*

The Council Directive 92/57/EEC instructed all the member countries in the EU to enact legislation to implement Prevention tough Design in Construction. Such examples are the Construction (Design and Management) Regulations in the UK (Government 2007), and the Royal Decree 1627/1997 in Spain (INSHT 1997).

# EMPHASIS ON FALLS FROM HEIGHT AS A PtD CONCENTRATION

It is evident from the Lorent and the Eurofound reports that the author concentrated on just falls from heights. The concentration on falls from height is an obvious one to consider, since this type of accident is the accident that is the 'big killer' for construction workers. Falls from height is a type of accident for which it is also easy to see that there are some things that designers can do to reduce the risk of falling, and the immediate causes of the accident are often fairly transparent compared to other accident types.

In South Africa for example, falls from height contributed to 12.8% of all accidents, and 17.2% of fatalities. Therefore, they clearly are a problem and should be focused on but PtD efforts should not be limited to combating these types of accidents alone. Design impacts many other aspects of the construction work in addition to work at height. Research performed in the past 20 years suggests that design plays a role in many different types of hazards present on construction sites. These hazards can result in different types of accidents (falls from height, trips/slips, struck-by, etc.). Targeting other accident types in addition to falls from height should be included to obtain a comprehensive perspective of the potential impact of the design. In addition, the analysis should address the range of injury severities (e.g., low, medium, high severity).

# SUGGESTIONS FOR THE FUTURE

The Lorent (1987) and the Eurofound (1991) reports were a starting point in attempting to establish a link between upstream factors and construction site accidents. However, the unquestioning reliance on the Eurofound statistics in making the case for safety in design in the construction industry is counter-productive. In Australia design professionals have argued against the validity of the Eurofound findings, correctly stating that the data does not link 60% of all fatalities to design. This argument about percentages and attribution has been a distraction in the debate and discussion about how best to improve OSH by integrating consideration of OSH into all stages of construction project decision-making.

What is also important to consider, is to use more recent and more reliable information when OSH professionals want to display a causality between design and construction fatalities or injuries. Such examples could be research by Behm (2005) and Haslam et al. (2005). To strengthen the reliability and plausibility of any OSH research, primary sources should be found, understood, and utilized rather than relying on others to cite those sources and then so on and so forth. In addition OSH authors and policy makers must ensure that cited research must also be rigorous and scientifically founded.

A more nuanced understanding of the potential for design to contribute to better OSH outcomes is perhaps needed. When considering design as a causal factor, it is important to understand what is being designed, e.g. is it the product, the process of construction, an item of plant or equipment, or a component/system to be installed? Hazards can also emerge at the interface of different design tasks and components. Understanding the socio-technical complexity of design work in construction, rather than attempting to attribute responsibility to a single professional role, e.g. the architect or engineer, is also important. Identifying and promoting the best ways to ensure that OSH is effectively integrated into all project decision making, during planning, design, procurement, construction, and commissioning, should be a research priority.

When it comes to the implementation of the legislation already in place, like in Europe, there seems to be less of possibility for change. Construction industry professionals will most likely have to 'get on with' applying the legislation – so, arguably there is a different driver, that of moral responsibility. Elsewhere though, it is less clear.

Without argument, more thought put earlier in the process will improve things for construction workers. However, that is very different from attributing causality or blame, and as a result, the concept of 'design' should extend beyond architects and structural engineers to also include planners, estimators and other people who 'design' the work place and work tasks rather than JUST the permanent work (the product).

Upstream decisions, e.g. the design of a building/structure, can have an impact on the construction methods chosen, which, in turn, impacts on site-based activities. Rather than identifying a single cause, it is more appropriate to understand accidents as arising as a result of a complex interaction of causes some of which relate to design and the organizational aspects of construction projects, e.g. procurement, client specifications, project management environment, etc.

Arguably, instead of trying to identify a percentage of accidents that are attributed to design, it is important to make all participants in the supply chain of constructing a project acknowledge that they sometimes have the potential to influence OSH through their decision-making. If this is acknowledged, then construction project participants can be encouraged to consider the OSH implications of their decisions and make decisions that are responsible and good for OSH.

Lastly, we contend that there has been enough research linking design to negative construction outcomes. Instead, future research should focus on how design enables safety to occur on construction sites.

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